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FAA Technical Center
Atlantic City International Airport
N.J. 08405

Federal Aviation Administration Small Business Innovation Research 5-Year Project Summaries

Office of Research and Technology Applications

February 1990

Final Report

U.S. Department of Transportation
Federal Aviation Administration

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16. Abstract

This document contains a summary of all Small Business Innovation Research (SBIR) Phase I and Phase II contract awards sponsored, either fully or on a shared cost basis, by the Federal Aviation Administration (FAA). The research projects contained in this document provide information on each project, including company, principal investigator, contract number, period of performance, FAA technical monitor, and either a summary of the proposed research and anticipated results or a summary of the completed research. This document covers research conducted over a 5-year period from 1985 through 1989.

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FORWARD

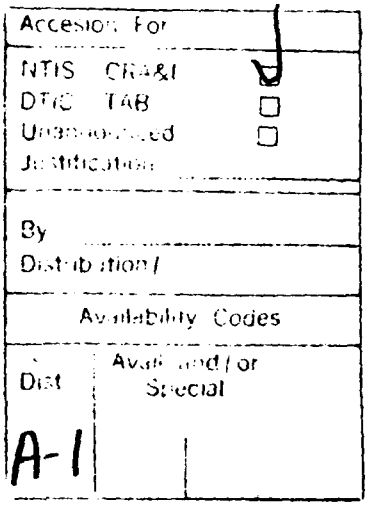
The Small Business Innovation Research (SBIR) program, as established by law, benefits both small businesses and government agencies. Small businesses benefit by having the opportunity to obtain government funds so that they may pursue the development of an idea or concept to the point of commercialization. Government agencies benefit by providing the means for small businesses to conduct research in topic areas that are important to the general public.

The implementation of the SBIR program in the Federal Aviation Administration (FAA) is as an agency wide program. The research topics for the current year program are the result of an agency wide solicitation. Evaluators for proposals are recruited from many agency organizational elements.

The purpose of this report is to provide information to all FAA elements and other interested parties on the results of FAA SBJR contracts for the past five years. Summary information is provided on completed as well as on-going research. It is intended that an update for the most recent five years be published annually.

A.A. Lupinetti

FAA SBIR Program Manager



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INTRODUCTION

Background The Small Business Innovation Research (SBIR) program is a phased process, uniform throughout the Federal government, of soliciting proposals and awarding funding agreements for research or research and development (R&D) to meet stated agency needs or missions. The SBIR program is a result of the Small Business Innovation Development Act of 1982 (PL97-219). The purposes of the Act are 1) to stimulate technological innovation, 2) to use small business to meet Federal R&D needs, 3) to increase private sector commercialization of innovations derived from Federal R&D, and 4) to foster and encourage minority and disadvantaged participation in technological innovation.

The Department of Transportation (DOT) annually issues an SBIR solicitation that sets forth a substantial number of research topics or R&D topics and subtopic areas consistent with stated modal agency needs or missions. The Federal Aviation Administration (FAA), as an operating administration of the DOT, provides topics for which proposals are to be considered for acceptance by DOT. Both the list of topics and the description of the topics and subtopics are sufficiently comprehensive and provide a wide range of opportunity for small business concerns to participate in FAA research or R&D programs. Topics and subtopics emphasize the need for proposals with advanced concepts to meet specific FAA research or R&D needs. Each topic and subtopic describe the needs in sufficient detail so as to assist small firms in providing on-target responses, but they do not involve detailed specifications to prescribed solutions of the problems. Unsolicited proposals or proposals not responding to the stated topics or subtopics are not eligible for SBIR awards.

To stimulate and foster technological innovation, including increasing private sector applications of Federal R&D, the program follows a uniform process of three phases.

Phase I. This phase involves a solicitation of proposals to conduct feasibility related experimental or theoretical research or R&D efforts on described agency requirements. The object of this phase is to determine the technical feasibility of the proposed effort and the quality of performance of the small firm with a relatively small agency investment before consideration of further Federal support in Phase II.

Several different proposed solutions to a given problem may be funded. Awards are made primarily on the basis of scientific and technical merit. Secondary considerations may include program balance, critical agency requirements, and whether the proposal indicates potential commercial applications in addition to meeting agency needs. Only awardees of Phase I are eligible to participate in Phase II.

Phase II. This Phase is the principal research or development effort. Funding is based upon the results of Phase I and the scientific and technical merit of the Phase II proposal. The object is to continue the research or R&D initiated under Phase I on agency needs. Phase II awards may not necessarily complete the total research and development that may be required to satisfy commercial or federal needs beyond the SBIR program. Completion of the research and development may be through Phase III. The Government is not obligated to fund any specific Phase II proposal. The Phase II award decision requires, where proposals are evaluated as being of approximately equal merit, that special consideration be given to proposals that have demonstrated third-phase, non-Federal capital commitments.

Because the program is intended to increase the use of small business firms in Federal R&D, for Phase I a minimum of two-thirds of the research and/or analytical effort must be performed by the proposing firm. For Phase II a minimum of one-half of the research and/or analytical effort must be performed by the proposing firm. For both Phase I and II the primary employment of the principal investigator must be with the small business firm at the time of award and during the conduct of the proposed effort. All research or R&D work must be performed by the small business concern in the United States, its territories and possessions. For further information about the SBIR program, contact:

U.S. Department of Transportation
Research and Special Programs Administration
Transportation Systems Center, DTS-23
Kendall Square
Cambridge, Massachusetts 02142
FTS: 837-2051
COMM: 617-494-2051

PHASE I FY-90 TOPICS

Projects will be chosen from the following SBIR Solicitation topics:

AIRCRAFT SAFETY

90-FA1. Aerosol Can Design Improvement for Fire Safety
90-FA2. Aircraft Electromagnetic Hazards
90-FA3. Aircraft Icing Protection
90-FA4. Turbine Engine Rotor System Failure Prediction and Prevention
90-FA5. Certification/Assessment of Novel Aircraft Configurations

AIR TRAFFIC CONTROL/FLIGHT SERVICES TECHNOLOGY

90-FA6. Advanced Communications Technology
90-FA7. Air Traffic Systems Technology for the Tiltrotor

AIRPORT TECHNOLOGY

90-FA8. Fog and Snow Removal Along Approach Paths and Runways at Airports

HUMAN FACTORS

90-FA9. Aviation Systems Simulation Effectiveness
90-FA10. Workload Reduction for Single Pilot Operations

INFORMATION TECHNOLOGY

90-FA11. Integrated Intelligent Technology System

FUNDING: ($M) (Statutory plus Project Funded)

FY-86	FY-87	FY-88	FY-89	FY-90
1.818	2.227	2.384	1.950	2.500(Est.)

RESEARCH ABSTRACTS

The following research abstracts are for all Phase I and II contract awards sponsored, either fully or on a shared cost basis, by the FAA. They are for the most part taken from project and proposal summaries submitted by the contractors. The research projects contained in this document cover a five-year period, FY-85 through FY-89.

FY-89 Phase II

Project Title: Development of Advanced Fan Blade Containment System

Principal Investigator: Alan D. Lane

Company: Advanced Structures Technology, Inc.
2849 South 44th Street
Phoenix, AZ 85040

Contract Number:

Period of Performance:

Technical Monitor: Bruce Fenton, ACD-210

Summary of Proposed Research: Phase I results indicated that ceramic -based containment systems have the potential for improved weight effectiveness compared to current systems. They also have the capability to withstand operating temperatures common in the turbine sections of modern engines. A total of three separate options are offered to provide flexibility in selecting the program responsive to FAA needs. The first and second options both consist of gas gun testing of Kevlar and Boron Carbide/Spectra containment rings. The options are 60 and 24 inch diameter rings which are representative of 20000 and 2500 lb. thrust engines resprctively. The objective of the gas gun tests is to compare the weight efficiencies of Kevlar and Boron Carbide/Spectra for fan blade containment.

A third option is offered to design and fabricate ceramic -based containment rings of 14 inch diameter for turbine disk burst testing. This option provides a vehicle for taking advantage of both the penetration preventation and high temperature capabilities of the ceramic materials. The FAA has tentatively chosen to pursue the third option.

Anticipated Results: This technology will allow the design of higher thrust-to-weight ratio turbine engines. It can be used either for new designs, or for retrofit application for existing engines.

FY-89 Phase II

Project Title: Fiber Reinforced Structures for Turbine Engine Fragment Containment

Principal Investigator: John Pepin

Company: Pepin Associates, Inc
Bldg. 4A Thompson's Point
Portland, ME 04102

Contract Number:

Period of Performance:

Technical Monitor: Bruce Fenton, ACD-210

Summary of Proposed Research: The proposed Phase II program builds upon Phase I results by developing two fiber reinforced structures for lightweight containment of turbine rotor failures. The first is a hybrid core sandwich panel capable of being used as a part of the airframe or nacelle structure and as a containment panel, if required. The second is a collar or ring placed close to the turbine case wall of a turbofan, turboprop or turboshaft engine. The program focuses on design of these structures to contain a 1 million in-lb tri-hub rotor burst using the lowest weight containment structure.

These goals will be met by sandwich panel and ring design tasks, test article fabrication and spin pit testing. Design modification and subsequent testing will develop an understanding of the relationship between reinforcement architecture, static/elastic behavior and dynamic impact behavior of the ring and panel. Additional spin pit testing is performed to evaluate changes in geometry and panel-to-panel joint designs. Recommendations are then made on design approaches to integrate the ring and panel structures in typical helicopter and aircraft engine installations.

Anticipated Results: This project will result in lightweight, energy absorbing material architectures which can be designed into engine and airframe structures to reduce the weight penalty for containment of internal turbine engine failures.

FY-89 Phase II

Project Title: Glass Bottle Contents Verification System

Principal Investigator: Dr. Dale R. McKay

Company: Quantum Magnetics, Inc.

Contract Number:

Period of Performance:

Technical Monitor: Hector Daiutolo, ACD-120

Summary of Proposed Research: The principal objective of the Phase II program is to develop, test and evaluate the performance of a prototype glass bottle contents verification system based upon Nuclear Magnetic Resonance technology. The specific technical objectives of the Phase II program are as follows:

1. Design and construct a prototype system to demonstrate the ability of NMR to discriminate between hazardous and benign fluids contained in sealed glass bottles.

2. Evaluate the performance of the laboratory prototype; conduct measurements on a variety of fluids and bottle configurations to identify and characterize the parameters important to the design of a field usable system.

3. Incorporate the improvements identified during the laboratory tests, above. Prepare the prototype system for field tests.

4. Evaluate the performance of the prototype system in both laboratory and field settings to determine its potential value as a security tool. Evaluate the system both in the laboratory and under actual inspection conditions.

Anticipated Results: Upon achievement of the program technical objectives, the Phase II work will demonstrate the feasibility of a field-usable glass bottle contents verification system using nuclear magnetic resonance. At the conclusion of Phase II, the prototype instrument will serve as a model for a commercial inspection system, and it is the intent of Quantum Magnetics to transfer the technology to Quantum Design to commercialize the technology in Phase III.

FY-89 Phase I

Project Title: Surface Traffic Automation Using Neural Networks

Principal Investigator: Dr. Robert Pap

Company: Accurate Automation Corporation
409 Chestnut Street, Suite A-180
Chattanooga, TN 37402

Contract Number:

Period of Performance:

Technical Monitor: George Booth , ADS-120

Summary of Proposed Research: This project will implement a new approach to identifying aircraft during ground operations. Neural network technology will be applied for scheduling and tracking aircraft. This robust and massively parallel automation technique has potential application for ground traffic management. Our concept should work with runway footprint detection schemes. It has the potential to do pattern recognition when integrated with ASDE-3 equipment that will provide a better image for controller situation viewing. This technique can be implemented based upon the supervised learning concepts and potentially in custom silicon or advanced personal computers.

The system software will will also use Hierarchical Scene Structures that permit better identification of targets viewed from different angles. Additionally, this technique will improve the speed and accuracy of target identifications from views taken while the target and/or radar is in motion.

Anticipated Results: This new approach to object classification will permit expansion beyond today's vision/radio system or ASDE-3 enhanced system. It will have a wide variety of applications in which present air traffic control systems are not practical.

FY-89 Phase I

Project Title: Information Display Structures

Principal Investigator: Thomas D. Watson

Company: Allotech, Inc.
715 W. Johnson St.
Raleigh, NC 27603-1229

Contract Number: DTRS-57-89-C-00138

Period of Performance: 1 Oct 89 -

Technical Monitor: Ray Kelly, ACD-120

Summary of Proposed Research: This project seeks to study the feasibility of applying theoretical models of human perceptual processing to establish better communication of information to humans from their technological environment. This study will draw upon the literature of perceptual and neurophysiological information. It will include theoretical work and demonstration displays. Three areas will be considered:

1) Optimizing the structure of information for human perception through non-orthogonal dimensions in information display,
2) Complex auditory display [VOXEL $_{tm}$],
3) Three-dimensional visual display [3-Space $_{tm}$].

Anticipated Results: All three components of this project, the plan view 3-Space(tm) display, the Voxel(tm) multichannel auditory display, and the theory of optimal information structure in displays have applications in control consoles.

FY-89 Phase I

Project Title: A Systems Approach to Security Checkpoint Optimization

Principal Investigator: Frank J. Englert

Company: International Productivity Services, Inc.
PO Box 595015, Miami International Airport
Miami, Florida 33159

Contract Number: DTRS-57-87-00165

Period of Performance: 1 Oct 89 -

Technical Monitor: Roy Mason, ACD-120

Summary of Proposed Research: This research will identify both the qualitative and quantitative aspects of security checkpoint operations. Using Industrial Engineering techniques, screening operations will be broken into basic elements which will then be measured and investigated to determine the interrelationships between such components as: 1) processing rates 2) distribution of passenger arrivals, 3) boarding volumes, 4) level of technological sophistication of screening equipment. The system will then be optimized using statistical and operations research techniques . The final objective of this research is to develop a prototype security checkpoint model that verifies the feasibility of establishing a general methodology applicable under any set of conditions which systematically optimizes all security checkpoint variables, including manning, layout, equipment, training, and supervision.

Anticipated Results: Further commercial applications will be investigated which involve the development of a marketable management tool in the form of an easy to use package of microcomputer software and working methodology which seeks to optimize a given set of operating requirements.

FY-89 Phase I

Project Title: PC Based Design and Procedural Development Tool

Principal Investigator: John D. Illgen

Company: Illgen Simulation Technologies, Inc.
351 South Hitchcock Way, Suite B230
Santa Barbara, California 93105

Contract Number:

Period of Performance:

Technical Monitor: Herbert Goldstein, AOR-100

Summary of Proposed Research: " The FAA has a need to build more efficient airspace and to develop more effective procedures in the utilization of that airspace." The objective of this effort is to provide an implementation plan to the FAA Operations Analysis Division that includes a detailed roadmap in identifying existing models and simulations and associated user input and documentation that can be used to simulate performance versus cost versus service for those systems that are presented in the National Airspace Plan. This will facilitate the means to quantitatively monitor NAS systems as they pass through the acquisition process (fixes and modifications to existing systems as well as newly evolving systems) and eventually conduct large-scale combined simulations of the National Airspace. The implementation plan will also provide direction to fill voids identified in the FAA modeling and simulation process. This effort will include the design and careful match of existing FAA computer hardware, languages, and software to meet modeling and simulation requirements.

Anticipated Results: This project will provide FAA facilities a credible, standardized simulation to individually and collectively evaluate airspace requirements and design (improvements, updates, new technology), traffic scenarios, and procedures to enhance effectiveness of FAA facilities and their collective impacts on the NAS. This will be accomplished by networking systems, PCs and other pertinent, available FAA computer resources via an ADP network using existing FAA resources in Phase II.

FY-89 Phase I

Project Title: Advanced De-icing Fluids for General Aviation Aircraft

Principal Investigator: Jerry L. Jordan

Company: Kohlmann Aviation Corp.
319 Perry Street
Lawrence, KS 66044

Contract Number:

Period of Performance:

Technical Monitor: Charles Masters, ACD-230

Summary of Proposed Research: The proposed project will determine the feasibility of the use of new Type I and advanced Type II fluids for the de-icing/anti-icing of General Aviation (GA) aircraft with takeoff safety speeds of generally less than 85 knots.

Type I and II fluids will be applied to several GA category aircraft.
The ice protection capability of the fluids will be evaluated for different freezing precipitation conditions. The effects of remaining fluid on the aircraft after takeoff rotation will be evaluated. These effects will be quantified in terms of handling and performance characteristics. The program will include field trials wherein the holdover properties of type I and II fluids will be evaluated.

Anticipated Results: Effective ground ice protection for GA aircraft by using new Type I and advanced Type II fluids will be enhanced. These fluids will benefit both commercial and military applications since their hold time from de-ice to yakeoff is frequently substantially longer than is typical for GA aircraft.

FY-89 Phase I

Project Title: Application of the COPILOT Artificial Intelligence System to MCC Needs

Principal Investigator: Dr. Stan Kaplan

Company: Pickard, Lowe and Garrrick, Inc.
2260 University Drive
Newport Beach, CA 92660

Contract Number:

Period of Performance:

Technical Monitor: John Wiley, ACD-350

Summary of Proposed Research: This firm has developed, via SBIR Phase I and II funding, the COPILOT expert system as an aid to online fault diagnosis and decision support for nuclear power plant control rooms. This system employs innovative knowledge representation schemabuilt around Bayesian principles, explicit and correct treatment of uncertainty, and the ability to handle trajectory type time-dependent instrument readings as a primary source of evidentiary information. The system is well suited to training applications, is flexible and adaptable to changing conditions, and can incorporate the evidentiary impact of human operator actions. The system is growable in the sense that, at early stages of development, the system is already capable of being used and providing value. Each new increment of development enhances its value by enlarging the diagnostic scope of the system without requiring changes to the work already done.

Since the fault diagnosis/isolation reqiurements of the Maintenance Control Center(MCC) are analogous to those of a nuclear plant control room, COPILOT could logically be applied to the MCC. Primary development will focus on the synthesis of a knowledge base in COPILOT format for the equipment whose faults COPILOT will diagnose. Despite the close analogy, problems in MCC applications will probably be encountered, requiring new ideas, methods, and the extension and modification of the COPILOT software.

Because of the "growable" feature, a usable product should be obtained very early in the project, allowing the Federal Aviation Administration(FAA) to judge and guide the development of further increments.

Anticipated Results: The anticipated results of this study will be to prove, by actually doing it, that the COPILOT approach can be successfully and profitably applied to MCC needs. Subsequent work would expand the domain of applications to additional MCC requirements.

FY-89 Phase I

Project Title: Corrosion Detection in Aging Aircraft

Principal Investigator: Dr. John M. Carlyle

Company: Physical Acoustics Corp.
15 Princess Road
Lawrenceville, New Jersey 08648

Contract Number: DTRS-57-89-C-00139

Period of Performance: Sept 29, 1989 -

Technical Monitor: Thomas DeFiore, ACD-220

Summary of Proposed Research: A concept for the detection of corrosion in aging aircraft using acoustic emission monitoring is proposed. Corrosion will be located through the effect that it has on airframe strength (10% thinning results in 50% fatigue life reduction). Acoustic emission technology used on the F-111 fighter/ bomber will be adapted for use on commercial aircraft. Preliminary concept testing on a Boeing 720B has resulted in the detection of an unsuspected, hidden 0.5 inch crack in the co-pilot's windshield post, as well as the discovery that corroded areas generate more signals than uncorroded areas. The end product of the Phase I research will be the specification of a method for instrumenting, stressing, monitoring and analyzing an entire aircraft using acoustic emission to locate structural damage caused by corrosion.

Anticipated Results: Benefits of the research include increasing aircraft safety (Through the enhancement of inspection quality by reducing operator fatigue and boredom), and saving money on inspections (by reducing inspection time and aircraft down-time). Applications exist for every airline, as well as for military and general aviation.

FY-89 Phase I

Project Title: Video Image Processing of Airport Pavement Distress

Principal Investigator: Dr. James C. Kennedy Jr.

Company: Resource International, Inc.
281 Enterprise Drive
Westerville, OH 43081

Contract Number: DTRS-57-89-C-00141

Period of Performance: Sept 29 1989 -

Technical Monitor: Aston McLaughlin, ADS-240

Summary of Proposed Research: The work proposed under this project centers around a method to observe and measure the state of distress (including crack depth) in asphaltic and portland cement concrete runway pavements. The method of this proposed work employs a combination of two dimensional video imaging and ground penetration radar. The video images are recorded and processed digitally using pattern recognition software and firmware to capture the distressed site and and quantify the amount and type of distress. Ground penetration radar techniques will be used to establish crack depth and will be synchronized with the video imaging. This program will employ the Automatic Road Analyzer from Battelle Columbus Laboratories as well as the expertise of Highway Products International in the video imaging analysis of pavement distress.

Anticipated Results: The results of this work will supply an automated method of processing information (video images and radar signatures) to quantify surface and subsurface distresses which will be a significant and useful tool to the pavement community for identification and repair of distress in pavements.

Project Title: Explosives Vapor Sampling

Principal Investigator: Dr. Fritz K. Knorr

Company: ScienTech, Inc.
SE 1122 Latah (P.O. Box 118)
Pullman, WA 99163

Contract Number: DTRS-57-C-89-00137

Period of Performance: Sept 29 1989 -

Technical Monitor: Carmen Munafo, ACD-120

Summary of Proposed Research: A novel means is proposed to sample, collect and selectively detect explosives vapor by taking advantage of certain ionization characteristics in conjunction with employing a unique tandem ion mobility sampling, separation, and detection architecture. This process is based on Ion Mobility Spectrometry(IMS). The method proposed for development offers some unique advantages for collection and detection of explosive vapors in the atmosphere at very high sample flow rates while processing large sample volumes in real time.

Anticipated Results: The proposed technology, if proven successful, will produce state of the art explosive vapor detection instruments. Many personnel security screening installations, both nationally and internationally, could benefit from the equipment developed under this contract.

FY-89 Phase I

Project Title: Certification/Safety Assessment of Flying Qualities and Pilot Workload for Advanced Digital Fly-By-Wire Transport Aircraft

Principal Investigator: Irving L. Ashkenas

Company: Systems Technology, Inc.
13766 S. Hawthorne Blvd.
Hawthorne, CA 90250

Contract Number: DTRS-57-C-89-00140

Period of Performance: Sept 29 1989 -

Technical Monitor: Joseph Traybar, ACD-230

Summary of Proposed Research: The impact of the differences between advanced digital fly-by-wire (DFBW) and conventional transport aircraft control systems will be analyzed, enumerated, and illustrated. Particular attention will be paid to the effects which these new control modalities will have upon FAA airworthiness requirements and certification procedures. Some of the issues to be studied include: Digital fly-by-wire and fly-by-light:

Redundancy Levels
Digital Systems Features
Mechanizational Side Effects
Independent Backup Considerations
Unanticipated Environmental Effects
Generic Design Errors
Pilot Role Modifications with DFBW
Sidestick Manipulator
Integrated Propulsion Controls
Pilot Command/ Envelope Limiting
Task-Tailored Control

Potential solutions, or research steps required to obtain solutions, to the problems/issues posed by the differences in the aircraft control systems, will be outlined and discussed. The improved safety potential of DFBW aircraft by virtue of task-tailored handling qualities will receive particular attention.

Anticipated Results: Enhanced airworthiness and safety of future transport aircraft which will be beneficial both to commercial and military air transport operators, manufacturers, and the FAA.

Project Title: Trainer for Handbaggage X-Ray Inspection Operators to Improve Checkpoint Efficiency

Principal Investigator: Dr. Stanley Hack

Company: TAU Corporation
485 Alberto Way, Building D
Los Gatos, CA 95032-5405

Contract Number: DTRS-57-90-C-00007

Period of Performance: Oct 13 1989 -

Technical Monitor: Roy Mason, ACD-120

Summary of Proposed Research: Tau Corporation has proposed to develop a new, novel technique and associated instrumentation for training operators of airport X-ray security systems. The training provided by this new system will greatly improve security checkpoint efficiency. The instrumentation proposed for the trainer system uses commercially available, low cost personal computers, attached board- level image processors, and standard video monitors. The training process will be implemented in software and use expert systems techniques based on field proven personnel training protocols. The training protocol will be adaptive to provide a means for the system to alter the presentation of the instructional sequence based on the performance of the student. In order to minimize the the required image storage requirements of the training system, X-ray images of hand baggage and of the objects to be identified by the trainee(e.g., Threat weapons, typical toilet items, etc) will be stored separately. The images of the object to be identified and the pieces of hand baggage will be merged in an artifact free manner using techniques developed by Tau Corporation in its SBIR Phase I project, contract DTRS-57-87-C-00102. This technique also provides the system with a controlled and selectable set of image parameters that will be used in composing the presented image.

Anticipated Results: The development will result in a low-cost stand alone, PC-based training system for airport x-ray security system operators. The system will provide an efficient means of initial and refresher training of the operators which will result in increased security checkpoint efficiency.

FY-89 Phase I

Project Title: A PC-Based Simulator with Expert System for Airspace Design

Principal Investigator: Dr. Robert B. Wesson

Company: Wesson International, Inc.
1439 Circle Ridge
Austin, TX 78746

Contract Number:

Period of Performance:

Technical Monitor: George Booth, ADS-120

Summary of Proposed Research: It is proposed to develop and construct an IBM PC-compatible air traffic control simulator with voice I/O, an extensive database of geographical fixes, and conflict resolution via an expert system. The simulator will be designed to facilitate airspace design and procedures development. Capable of displaying a realtime radarscope picture of any geographical area, its sectors may be created via a simple user interface by field personnel. The simulator will generate realistic traffic flows, complete with "intelligent" pilots who "talk" using a synthesized voice and follow correct procedures. A manual mode will respond to voice commands issued by field personnel and accomodate informal comparisons, but an "automatic " mode could use an expert system to resolve conflicts and evaluate solutions quantitatively. Phase II work includes increasing the capability of this simulator by upgrading the expert system rules to improve conflict recognition and resolution and conducting field trials of the simulator at a real world ATC facility.

Anticipated Results: This simulator is expected to speed up the generation, testing and evaluation of alternative airspace sector designs. By quantifying this process, more efficient procedures can be created which will translate into cost savings for airspace users.

FY-89 Phase I

Project Title: ATC Man/Machine Interface Design Using a PC-Based Simulator

Principal Investigator: Dr. Robert B. Wesson

Company: Wesson International, Inc.
1439 Circle Ridge
Austin, TX 78746

Contract Number:

Period of Performance:

Technical Monitor: George Booth, ADS-120

Summary of Proposed Research: Innovative methods of man-machine communication will be proposed, implemented, and studied experimentally within the context of an existing high-fidelity PC-based ATC simulator (TRACON ™) . The specific possibilities include, but are not limited to, mouse/trackball-based popup and pulldown menus and dialog boxes, voice I/O for database lookup, digital communications including a tactical communications manager, plan-ahead monitor, and 3-D display hardware technology. A comprehensive design for Phase II further development and experimentation using the best of these concepts will also be included.

Anticipated Results: New man/machine interfaces and communication technologies will be identified that could be incorporated into the upcoming 1990's ATC system to make the ATC specialist's automation management function easier, clearer, and thereby safer.

Project Title: A Compact Accelerator-Based Neutron Source for Baggage Interrogation

Principal Investigator: Dr. Robert W. Hamm

Company: AccSys Technology Inc.
1177A Quarry Lane
Pleasanton, CA 94566

Contract Number: DTRS-57-89-C-00019

Period of Performance: 1 Oct 88 -

Technical Monitor: Chris Seher, ACD-120

Summary of Proposed Research: The use of thermal neutrons for baggage inspection has been tested by the FAA in two prototype explosive detection units at selected airports. Although the feasibility of this technique has been established, a reliable, compact, preferably electrically-driven neutron source (i.e. no radioactive material) will be necessary if thermal neutron activation is to become a routine baggage explosives detection procedure. The Radio Frequency Quadrupole (RFQ) linear accelerator system designed in Phase I of this SBIR program will provide the required neutron flux in a compact, reliable, and easy to maintain and operate unit. This Phase II proposal is for the construction and testing of a prototype RFQ-based neutron source producing up to 8×10^9 neutrons/sec using 900kev deuterium ions bombarding a beryllium target. The complete RFQ linac system is only 48" long and requires an input peak RF power of only 35 kilowatts, operating at a maximum duty factor of 3 percent with a pulse repetition rate of up to 2000 pulses per second. The modular configuration of this system and its simple operation make it an ideal neutron source for airport baggage inspection by thermal neutron activation.

Anticipated Results: The proposed research will produce a reliable, compact RFQ linac designed for operation as an electrically-driven neutron source for use in the FAA explosive detection system. This compact neutron source will also have application in commercial neutron activation analysis of minerals, trace elements, and chemicals.

FY-88 Phase II

Project Title: False Image Threat Projection and Development[1]

Principal Investigator: Andreas Kotowski

Company: Astrophysics Research Corp.
4031 Via Oro Ave.
Long Beach, CA 90801

Contract Number:

Period of Performance: 1 Oct 88 -

Technical Monitor: Roy Mason, ACD-120

Summary of Proposed Research: A security operator training system based on the use of false image projection will be developed. The system is based on computer-controlled programmed learning using a database of luggage images and threat images. Individual luggage images are combined with individual threat images to provide a very large number of combined images. The system allows off-line training and evaluation of security X-Ray machine operators.

Anticipated Results: A prototype X-Ray security operator training system based on the projection of threat images will be developed.

[1] Although initially proposed and selected under the SBIR Program, Astrophysics Research has been acquired by EG&G, disqualifying itself from receiving SBIR funding.

FY-88 Phase II

Project Title: Post-Crash Aircraft Fuel-Fed Fire Prevention

Principal Investigator: Michael Beltran

Company: Beltran, Inc.
1133 E. 35th Street
Brooklyn, New York 11210

Contract Number: DTRS-57-89-C-00066

Period of Performance: 1 Oct 88 -

Technical Monitor: Eugene Klueg, ACD-210

Summary of Proposed Research: This project seeks to develop cost-effective methods to mitigate or obviate post-crash jet fuel-fed fires through the use of visco-modified fuels (VMF), rapid jelling or emulsification, halon injection, and open cell foams in combination with VMF. It builds upon the work conducted in the Phase I project which determined the feasibility of fuel modification techniques and their ease or difficulty of implementation. The Phase II study will evaluate advanced VMF concepts, for example tensile and shear thickening additives, which are tailored to provide maximum benefits in terms of mist elimination and shear-thickening to reduce spread during the crash. The Phase II program will develop small scale combustion test apparatus as well as determine the spray and pool fire flammability and fuel dispersion characteristics of the various concepts. The most promising techniques will be evaluated for a jet aircraft configuration to determine the total system requirements. Areas requiring further study or evaluation will be highlighted.

Anticipated Results: The research will develop additives and/ or techniques which will mitigate or eliminate post-crash, fuel-fed fires. When implemented, this will save lives, reduce damage to property and decrease costs. The results will be applicable to commercial, private, and military jet aircraft.

Project Title: Workload Assessment Technologies for the Optimization of Data Link Controller Procedures

Principal Investigator: Clark A. Shingledecker, Ph.D.

Company: NTI, Inc.
4130 Linden Ave., Suite 235
Dayton, OH 45432

Contract Number: DTRS-57-89-C-00021

Period of Performance: 1 Oct 88 -

Technical Monitor: Nick Talotta, ACD-320

Summary of Proposed Research: The Mode S data link under development by the FAA is an essential upgrade to the existing ATC system. In order to insure the improvements in ATC safety and efficiency offered by this technological advancement, it will be necessary to assess its effects on the workload and performance capabilities of air traffic controllers.

The Phase II research proposed by NTI, Inc., will employ a variety of workload and performance metrics identified in Phase I in a series of design and operational evaluation studies to be conducted by the FAA for the purpose of developing optimal procedures and controller interfaces for data link mediated ATC services. The results of these studies will form the basis for the development of a prototype standardized battery of controller assessment technologies for future use in the evaluation of FAA ATC automation initiatives.

Anticipated Results: This effort will provide the FAA with a standardized controller assessment tool for application during the conceptual, design, and evaluation phases of automated system development. Direct commercial applications are anticipated in process control and transportation industries.

FY-88 Phase II

Project Title: Squid NMR for Explosives Detection

Principal Investigator: Dr. Ronald E. Sager

Company: Quantum Magnetics, Inc.
11578 Sorrento Valley Road, Suite 30
San Diego, CA 92121

Contract Number: DTRS-57-89-C-00014

Period of Performance: 1 Oct 88 -

Technical Monitor: Chris Seher, ACD-120

Summary of Proposed Research: A nuclear magnetic resonance (NMR) system to inspect airline baggage for the presence of flat-sheet explosives is proposed. The system is designed to respond to the presence of PETN which is a principal component of all flat-sheet explosives. Distinguishing features of the system include the use of a surface coil geometry and a superconducting quantum interference device (SQUID) detection system. Although PETN is not detectable by conventional surface-coil techniques, the SQUID detector is a low-noise device with the sensitivity to detect the proton NMR signal from PETN directly.

Anticipated Results: At the conclusion of this program, an instrument system capable of rapid and accurate detection of flat-sheet explosives in airline luggage will have been demonstrated. When fully developed, the system will greatly enhance airport security. The detection technique may also find application in checkpoints at embassies, FBI offices, and other terrorist targets throughout the world.

Project Title: Computer Voice and Speech Data Entry and Recognition

Principal Investigator: Philip C. Shinn, Ph.D.

Company: Speech Systems, Inc.
18356 Oxnard Street
Tarzana, CA 91356

Contract Number: DTRS-57-89-C-00016

Period of Performance: 1 Oct 88 -

Technical Monitor: George Booth, ADS-120

Summary of Proposed Research: Capabilities of the current speech recognition system for ATC application will be enhanced to attain better recognition performance and increase the speed of *recognition*. *Recognition* speed and accuracy will be improved by three methods: 1) building vocabulary-independent, speaker-independent recognition models that are enhanced for ATC applications, 2) improving current search algorithms to be more efficient in their use of computational resources, and 3) continuing the development of ATC syntax.

Anticipated Results: Results are expected in two areas:
1) improved man-machine interface with computers, and
2) increased ease of and efficiency in ATC employee performance.

FY-88 Phase I

Project Title: Development of an Advanced Fan Blade Containment System

Principal Investigator: Dr. Alan D. Lane

Company: Advanced Structures Technology, Inc.
2849 S. 44 th Street
Phoenix, AZ 85040

Contract Number: DTRS-57-88-C-00117

Period of Performance: 10 Oct 88 - 7 April 89

Technical Monitor: Bruce Fenton, ACD-210

Summary of Completed Research: The principal objective of this study was to investigate the potential weight savings using a ceramic-based turbine blade containment system. Technology developed to provide lightweight armor for aircraft has shown that systems using ceramic (Al_2O, SiC, and B_4C) are more weight efficient than metals (steel, titanium, and aluminum), or polymer fibers (fiberglass and kevlar).

Phase I was broken into three primary sub-tasks. These were:

1. Design a ceramic-based fan blade containment system for maximum weight effectiveness.
2. Compare the ceramic containment system with current metal and Kevlar systems to quantify the potential weight and cost improvement.
3. Develop a complete test plan, including the design of test fixtures and test articles to allow verification of improved weight effectiveness of ceramic-based systems.

Conclusions reached during the program were:

1. Armor test data shows that B_4C/Spectra is more weight effective than Kevlar for defeating projectile penetration.
2. The ratio of B_4C/Spectra weight effectiveness to that of Kevlar is larger for higher kinetic energy projectiles.
3. The weight effectiveness of B_4C/Spectra versus Kevlar containment is significant for engines of 200000 lb. or greater thrust.

FY-88 Phase I

Project Title: Shadowgraph Enhancement

Principal Investigator: Andreas Kotowski

Company: Astrophysics Research Corp.
4031 Via Oro Ave.
Long Beach, Ca 90801

Contract Number: DTRS-57-89-C-00002

Period of Performance: 1 Oct 88 - 5 May 89

Technical Monitor: Roy Mason, ACD-120

Summary of Completed Research: The concept of automatically analyzing x-ray images of luggage for the presence of guns has been found to be promising. A metallic threat detection algorithm was developed and tested against a variety of different handguns. It was found that most guns can be reliably detected. Several common features of luggage mimic guns and are not automatically ignored. Therefore, the system would need to be used to highlight the areas of the image to be more closely inspected by the operator. Explosive threat detection was only tried with standard (black and white) images. It was not possible to acquire realistic E-Scan images in time for this study. As expected , the results did not look promising. Astrophysics has requested and received data to alow continued research in this area with realistic explosive simulants. Based on the results of this Phase I study, Astrophysics intends to continue research in this area with support from its acquiring company, EG&G Corporation.

Project Title: TCAS I Development

Principal Investigator: Gene Horlander

Company: Gene Horlander/ACOM Microwave
8805 Denise Drive
Louisville, KY 40219

Contract Number: DTRS-57-88-C-00111

Period of Performance: 1 Oct 88 - 25 June 89

Technical Monitor: Joseph Walsh, ASA-120

Summary of Completed Research: The objective of this project was to develop an inexpensive Traffic Alert and Collision Avoidance System (TCAS) I for general and commuter aircraft requirements. The net result was that ACOM produced a working laboratory breadboard TCAS 2 system employing the active approach, which ACOM believes to be more reliable than a passive system. The prototype TCAS is microprocessor controlled, interfaces to the aircraft avionics bus, comprises two small aluminum rack mounted chassis and operates using standard aircraft power. It employs software controlled whisper-shout transmission, adjusts power output per power budget limitations, and interfaces to the on-board Mode C or Mode S transponder. The TCAS I prototype also has angle of arrival capabilities, supports up to four decoders and supports garble and phantom detection. An alpha-beta filter is implemented in software and lost and relative target aircraft are displayed using a PPI type display. the antenna is directional and bottom mounted. All subsystems and the overall prototype were bench tested. The target TCAS I price, excluding installation is less than $10,000.

FY-88 Phase I

Project Title: Neural Networks for Air Traffic Control

Principal Investigator: Dan Greenwood

Company: Netrologic Inc.
4241 Jutland Drive
San Diego, CA 92117

Contract Number: DTRS-57-88-C00115

Period of Performance: 1 Oct 89 - 1 April 89

Summary of Completed Research: The air traffic controller's task is very complicated because of the very large number of factors one has to consider when handling a number of aircraft simultaneously. A neural network approach to air traffic control processing has natural advantages since networks can be trained quickly to select which factors are relevant in specific circumstances, thereby reducing the complexity of the task to be solved. Neural networks can also be trained to deal with information processing for which rules cannot be articulated explicitly. Parallel operation of neural network paradigms give significant speed increases over sequential implementations with minimal hardware. Two distinct network models were implemented:

1. Conflict Field Air Traffic Interaction Mode (FIM): This model maintained and updated spatial coordinates for all objects in an arbitrary scenario simultaneously based on mission objectives and perceived collision threats and simulated the conflict environment. It used a heuristic motion control algorithm incorporating field effect interactions and gradient descent to minimize accident probability.

2. Reflex Response Trainable Network Model (ATC Network Controller): The commercially available TRACON ATC simulator served as the environment under neural network control. The system uses a small, fixed-dimensional input space and an expert system which handles details of the air traffic encounters.

Research Findings:

1. FIM shows that a large number of aircraft (at least 20) can be controlled and landed while maintaining a minimum required separation. The existing model may be enhanced by attributing to airplanes certain flight characteristics which provide further control capabilities.

2. ATC Network Controller is able to accept incoming aircraft maneuver them to appropriate waypoints, and hand them off to their destination's controller. While the existing functions and networks have been shown to resolve all problems which have been tried, training networks can provide optimal aircraft control. A fully functional and optimized version of either three approaches or a combination of them can be used for training air traffic controllers and advising during situations on-site.

FY-88 Phase I

Project Title: Network of Learning Systems for Air Traffic Control

Principal Investigator: Edward H. Patrick Ph.D. M.D.

Company: Patrick Consult Inc.
810 Matson Place
Cincinnati, Ohio 45204

Contract Number: DTRS-57-88-C-00114

Period of Performance: 1 Oct 88 - 7 April 89

Technical Monitor: George Booth, ADS-120

Summary of Completed Research: This research was conducted to investigate how to plan, schedule, and control air traffic utilizing a network of expert learning subsystems.

Research concentrated on multiple aircraft guided by approach control, tower, and ground control at an airport with satellite airports. A total system was designed consisting of different subsystems: conflict learning, and action learning subsystems. Theoretical modeling showed that for T aircraft T*(T-1) learning subsystems are required, but each subsystem can be trained with identical training examples. A feature list was developed, training examples obtained, and simulations performed and reports for a typical subsystem at a typical airport.

It appears that current neural net processor board technology can be used to implement the T*(T-1) learning systems for conflicts and also for actions with reasonable processing times.

Other aspects of the total system include actions involving scheduling of aircraft. Both the neural net and heuristic rule based technology can be and were implemented in a system manager.

The research demonstrates that a system can be developed using state of the art technology and trainable at multiple FAA airport facilities using real life examples from current ARTS equipment. The systems will be able to recognize conflicts and provide actions to resolve these conflicts. The system can be used both to train controllers and provide a prototype for future air traffic control. It would help improve safety as capacity increases and can provide outcome analyses of air and ground traffic.

FY-88 Phase I

Project Title: Fiber Reinforced Structures for Turbine Engine Fragment Containment

Principal Investigator: John Pepin

Company: Pepin Associates, Inc.
Bldg. 4A Thompson's Point
Portland, ME 04102

Contract Number: DTRS-57-89-C-00062

Period of Performance: March 2, 1989 - May 16, 1989

Technical Monitor: Bruce Fenton, ACD-210

Summary of Completed Research: This project examined new fibers and fiber architectures for turbine engine fragment containment and tested a new soft ballistic/hard structural core concept for an energy absorbing sandwich panel. Twelve by eighteen inch panels were fabricated and tested for their energy absorbing capacity by firing blade-like projectiles at them with a gas gun. The FAA's interest in containment of small turbine rotors led to the selection of polybenzbisoxazole (PBO) as a candidate fiber. Its useful temperature of 572 deg. F (300 deg. C) and good energy absorbing qualities make it potentially useful as a containment material proximate to the turbine wall. Since PBO is not currently available, polybenzbisthiazole (PBZT), was used to fabricate test panels.

For cowlings and bulkheads, the concept of a structural sandwich panel with a soft energy absorbing core and rigid crossing members was studied by sewing graphite prepreg yarn through a dry kevlar laminate and curing the graphite/epoxy to form a simulated hybrid sandwich panel core. Ballistic test data showed that the PBZT panels and Kevlar panels were about the same but the hybrid panels were better than the Kevlar baseline by 15-20% in energy absorbed. These results point to potential use for PBO in turbine containment collar structures and the hybrid panel panel in cowling and bulkhead structures. Anticipated Phase II work will include spin pit testing of these structures.

FY-88 Phase I

Project Title: Glass Bottle Contents Verification System

Principal Investigator: Dale R. McKay

Company: Quantum Magnetics, Inc.
11578 Sorrento Valley Road, Suite 30
San Diego, CA 92121

Contract Number: DTRS-57-88-C-00118

Period of Performance: 1 Oct 88 - 19 May 89

Technical Monitor: Hector Daiutolo, ACD-120

Summary of Completed Project: The goal of this Phase I effort to demonstrate the feasibility of developing a glass bottle contents verification system based upon Nuclear Magnetic Resonance (NMR) technology was successfully met. Discussions with the FAA had indicated that a problem existed in distinguishing harmless alcoholic beverages from explosive liquids in aircraft baggage. Tests found that an easily measured Nuclear Magnetic Resonance parameter, spin-lattice relaxation time, T_1 differs by a factor of two between the two classes of liquids. Experiments with various instrument configurations established that the design and construction of an instrument capable of distinguishing this difference in T_1 is straight-forward, involving familiar well developed technologies.

The T_1 measurements and other experiments were conducted in a laboratory environment. A demonstration system must be operated in an airport environment before the design can be finalized. The demonstration system has been specified and preliminary module level design for a commercial prototype has been completed.

In view of the probability that system requirements may change the detection system has been designed to be flexible and easy to modify. With these considerations in mind, possible supplements to the T_1 measurement were investigated. Specifically, spin density, the self diffusion constant, and spin-spin coupling could also be measured by the proposed system, and show considerable promise. The results of this research will lead to a rugged reliable inexpensive and simple verification system which should be useful wherever explosive liquids pose a security problem.

FY-88 Phase I

Project Title: NDI of Composite Structural Materials by Gamma Scatter Sensing

Principal Investigator: Charles C. Blatchley, Ph.D.

Company: Spire Corporation
Patriots Park
Bedford, MA 01730

Contract Number: DTRS-57-88-C-00116

Period of Performance: 1 Oct 88 - 15 May 89

Technical Monitor: Larry Neri, ACD-220

Summary of Completed Research: The objective of this Phase I research program was to evaluate the feasibility of using gamma ray backscatter radiometry (GRBR) for Nondestructive Inspection (NDI) of advanced polymer composite materials used in aircraft. Unlike conventional radiometry or radiography, gamma scatter requires access to just one surface, and through proper collimation it can be made to ignore surface features and sense only defects inside a composite structure. It can be extremely rugged; detectors and electronics similar to those for a hand-held inspection unit have been successfully boosted into space. Other potential uses include detecting incipient cracking or corrosion damage in structures already in use.
The following goals were accomplished during this project:

1. A computer code was developed to model backscatter performance for typical composite materials and collimator designs.
2. Preliminary designs were predicted to achieve levels of sensitivity determined necessary for rapid scanning based on a survey of common materials and defect problems.
3. Two promising configurations were constructed in bench scale models and tested to determine limits of accuracy, sensitivity, and reproducibility with simulated defects created by stacking separate composite specimens, leaving gaps in internal layers.
4. Testing indicated sizable linear changes in detected counting rate over a large range of defect sizes suggesting that a prototype scanning instrument should be able to achieve an order of magnitude greater sensitivity than competing techniques.
5. Results were evaluated along with cost estimates to support a conclusion of technical and commercial feasibility

A fieldable gamma scatter based NDI system will have broad use in commercial aviation for insuring structural integrity of composite materials. It will also find applications at the manufacturing, assembly, and operational levels, will reduce costs by relaxing design margins, increase material usage, and will open up new applications in gas turbine engines.

Project Title: Methodology for Correlation of ATC Controller Workload Errors

Principal Investigator: Elizabeth D. Murphy

Company: Computer Technology Associates, Inc.
5670 Greenwood Plaza Blvd., Suite 200
Englewood, Colorado 80111

Contract Number: DTRS-57-87-C-00107

Period of Performance: 1 Oct 87 - 2 Nov 89

Technical Monitor: W. Shepherd, AAM-500

Summary of Completed Research: This Phase II human factors project resulted in the development of an engineering tool for use in predicting the workload and performance of air traffic controllers in future transition states of the National Airspace System(NAS). This product, called PATCAM, the Predictive Air Traffic Control Model, provides a valid method of evaluating design changes early in the system development life cycle. Phase II activities focused on designing and implementing a powerful demonstration of PATCAM's capabilities Research activities included model enhancement and validation, development of controller task networks, and construction of databases representing validated operational activities for two future NAS transition states: the Advanced Automation System (AAS) and an AAS enhancement, the Advanced En Route Air Traffic Control (AERA 2) environment. The Phase II research led to the introduction of a new construct, the mental interface, to represent important cognitive structures that have not been previously considered in analyses of controller workload and performance.

PATCAM permits the comparison of predicted demands on the controller and his subsequent performance, as a function of available skills and cognitive resources. Comparisons can be made on the basis of simulated "critical incidents", which appear in the comparable AAS and AERA 2 scenarios. Because the AAS and AERA 2 operations concepts have evolved beyomd the baselines used for PATCAM development, results of the AAS and AERA 2 comparisons are presented for proof-of -concept purposes only. For example, results indicate that the simulated AERA 2 controller can deal with significantly more ATC situations than can the simulated AAS controller in the same amount of time, with no increase in task induced demand.

FY-87 Phase II

Project Title: Laboratory Investigation of Atmospheric Effects on Vortex Wakes

Principal Investigator: H. T. Liu

Company: Flow Research Company
21414 68th Ave. South
Kent, Washington 98032

Contract Number: DTRS-57-87-00109

Period of Performance: 1 Oct 87 - *

Technical Monitor: J. O'Neill, ACD-220

Summary of Proposed Research: The feasibility of conducting tow tank experiments was demonstrated to characterize aircraft vortices under the influence of atmospheric disturbances such as stratification, wind shear, and turbulence. Innovative methods were developed for simulating these disturbances and for quantifying ambient conditions and the vortex flow field. The aircraft vortices were simulated by an NACA 0012 wing, towed at several angles of attack, and by a 2-D vortex generator. A thin wire suspension system for the wing model was the key to achieving a contamination-free vortex wake for the proposed investigation. Visual experiments using fluorescent dye and microcapsules were conducted to characterize the vortex evolution. Several important discoveries were made in the Phase I research that would help improve the understanding of the behavior of aircraft vortices in an airport environment. The Phase II study will quantify a number of Phase I findings, including laboratory methods, and will probe measurements and visual experiments to characterize the ambient conditions and vortex flow fields near ground level. Additionally, a vortex-method code will be modified to study shear effects.

Anticipated Results: Data will be provided for reassessing the FAA separation standards. Information from this study will also be used for validating models developed as predictive tools for real-time air traffic control operations. The methodology can be used to test the effectiveness of new vortex-taming devices.

* 6 Month Contract Extention Granted

FY-87 Phase II

Project Title: Sensors for the Detection of Nonmetallic Weapons Concealed Upon Personnel

Principal Investigator: Lawrence E. Larson

Company: Medical Microwave Research Corp.
808 Pershing Dr., Suite #104
Silver Spring, Maryland 20910

Contract Number: DTRS-57-87-C-00110

Period of Performance: 1 Oct 87 - *

Technical Monitor: Ken Novakoff, ACD-120

Summary of Proposed Research: This project will develop a new concept for the detection of nonmetallic or metallic weapons concealed upon personnel by the use of noncontacting sensors. The detection and classification method is based on contrast between concealed weapons and their background. Metal detectors are not used. Phase I SBIR results have demonstrated detection feasibility and target classification. This project will increase data collection rates, add area scans for target shape, and add surface characteristics for use in target classification. The system is to be tested on human volunteers with various targets concealed in various sites under assorted types of clothing. The test results will be presented in terms of estimated probability of detection and estimated false alarm rates.

Anticipated Results: If fully successful, this novel system for the detection of concealed weapons will detect nonmetallic as well as metallic weapons concealed upon personnel with a 95 percent accuracy and a 5 percent false alarm rate for innocuous targets.

* Work currently in progress

FY-87 Phase II

Project Title: Airborne Forward Looking Low Level Wind Shear Sensor

Principal Investigator: Todd A. Cerni

Company: OPHIR Corporation
7333 West Jefferson Avenue, Suite 210
Lakewood, Colorado 80235

Contract Number: DTRS-57-87-C-00111

Period of Performance: 1 Oct 87 - *

Technical Monitor: John Reed, ACD-230

Summary of Proposed Research: The Phase I SBIR effort provided a clear and strong demonstration of the feasibility of an airborne forward-looking, low-level wind shear sensor based on a Doppler lidar. The proposed research effort will provide additional support for the Integrated FAA Wind Shear Program which began last year. It will complement rather than duplicate existing elements in that program. Doppler radars and Doppler lidars constitute the only practical options for airborne, forward-looking sensors. Airborne Doppler radars perform very well in wet microbursts but are not likely to detect dry microbursts. Airborne Doppler lidars perform very well in dry microbursts while performance in heavy rain is reduced, it is still adequate. Numerical modeling predictions indicate the proposed airborne Doppler lidar would have a range of 2 to 5 km for dry microbursts and 1 to 3 km in heavy rain. The proposed lidar would be based on an innovative systems concept that would minimize complexity and maximize cost effectiveness.

Anticipated Results: The proposed research will result in an airborne lidar wind shear sensing system design to be pursued commercially. If successful, the Doppler lidar promises to be an important safety aid for large commercial and military aircraft.

* Six Month Contract Extension Granted

Project Title: A Compact Accelerator-Based Neutron Source for Baggage Interrogation

Principal Investigator: Robert W. Hamm

Company: AccSys Technology, Inc.
1177 A Quarry Lane
Pleasanton, California 94566

Contract Number: DTRS-57-87-C-00084

Period of Performance: 1 Oct 87 - 1 Mar 88

Technical Monitor: C. Seher, ACD-220

Summary of Completed Research: The development of a system to routinely inspect for explosives in airport baggage using thermal neutron activation requires a compact, electrically- driven source of neutrons capable of a constant high flux over long periods of operation. The purpose of this Phase I design study was to complete the design of a compact accelerator-based source for this application.

A technical spinoff of the Strategic Defence Initiative research, ideal for this purpose, is the Radio Frequency Quadropole (RFQ) linear accelerator (linac). This compact 48 inch long 400 lb accelerator produces a neutron yield of 8×10^{9} neutrons/sec by bombarding a beryllium target with 900 kev deuterium ions. Electrical power requirements are less than 15 kw using standard commercial service. The compact size of the RFQ linac and its simple operation make it a suitable replacement for the electrostatic neutron generator tube currently used in this application, but with a longer target lifetime and greater neutron output.

The design of the components of this system has been completed and the system sensitivity to operating parameters has been established. The engineering calculations for the linac subsystem and the engineering drawings for the key linac components have been completed. It is anticipated that a prototype will be completed in Phase II. This accelerator has potential applications in any testing and examination technique which uses neutrons including nuclear waste assay, neutron activation mineral assay, and radiation testing.

Project Title: Traffic Management Concept Evaluation

Principal Investigator: Anna M. Okseniuk

Company: AKM Associates
635 Mariner's Island Boulevard, Suite 205
San Mateo, California 94404

Contract Number: DTRS-57-87-C-00086

Period of Performance: 1 Oct 87 - 31 Mar 88

Technical Monitor: L. Mosher, AES-320

Summary of Completed Research: During the Phase I feasibility study, AKM Associates developed an automated Air Traffic Flow Manager (ATFM) algorithm which will smooth air traffic flow over the entire network while maintaining safety and reducing delays. The main thrust of the Phase I effort was concentrated on en route rerouting strategy.

A dynamic programming heuristic paradigm was used to generate detours for selected aircraft. The detours generated by the algorithm do not cause future saturation problems if air traffic network conditions turn out to be what has been predicted by the Flow Manager. A scaled-down simulation of the air traffic flow, sector saturation detection, and aircraft rerouting modules has been implemented on a Symbolics 3650 AI workstation using Common Lisp. A sample airspace which consists of 265 fixes, 50 routes, and 403 route segments has been implemented to validate the ATFM system.

In the simulation, the rerouting algorithm finds a detour instantly. In a real world environment, the execution time is expected to be a second or two. With additional work, a complete ATFM system will be capable of choosing and modifying flights to reroute, gate/ground hold, changing a destination, or a combination of these actions. This would result in maximizing economics and minimizing delays while maintaining safety.

FY-87 Phase I

Project Title: Remote Passenger Baggage Identification

Principal Investigator: Andreas Kotowski

Company: Astrophysics Research Corporation
4031 Via Oro Avenue, P.O. Box 22709
Long Beach, California 22709

Contract Number: DTRS-57-87-C-00126

Period of Performance: 1 Oct 87 - 27 Apr 88

Technical Monitor: R. Mason, ACD-120

Summary of Completed Research: The feasibility of developing a remote passenger baggage identification system that automatically identifies and tracks checked luggage was studied. A system utilizing electronically based luggage tags which would be interrogated via radio links was found to be technically feasible. The tags are estimated to cost as little as $1 each would last indefinitely. The tags would allow luggage passing a read station to be identified via a unique number assigned to each tag. The airlines' computer system would contain the database describing to which passenger each bag belonged and where the bag should be routed.

The immediate application of this system would be supporting of the baggage match requirement of ICAO Annex 17 Standard 5.1.4 of passenger baggage match. Peripheral benefits of better tracking of luggage would result. Presently, some airlines implement manual passenger baggage match. These airlines feel the cost saved with electronic system would not justify the tag cost. The tag would have to be reusable to be financially attractive. To be reusable all airlines would need a standard for the baggage tag so that any tag would operate with any reader, and every tag would be unique. This would require a national (FAA or ATA) standard, or an international standard (ICAO or ATA). Without governmental pressure such a standard is unlikely.

FY-87 Phase I

Project Title: X-Ray False Image Projection

Principal Investigator: Andreas Kotowski

Company: Astrophysics Research Corporation
4031 Via Oro Avenue, P.O. Box 22709
Long Beach, California 22709

Contract Number: DTRS-57-87-C-00125

Period of Performance: 1 Oct 87 - 28 Apr 88

Technical Monitor: R. Mason, ACD-120

Summary of Completed Research: The concept of projecting threat images into the image stream on security X-ray machines was studied and found to be feasible. A system based on this concept would potentially enhance the checkpoint security level. Several possible benefits are foreseen: 1) operator training by presentation of realistic threat images much more often than actually occur, 2) assurance and measurement of operator performance on the job in real time, 3) capability of adjusting the search level to the level dictated by the current threat level via selection of threat images presented.

Based on the results of this study, Astrophysics has decided to fund the development of an adjunct system compatible with its existing machines as well as becoming an option on future machines. A Phase II proposal is being submitted to develop a realistic, off-line operator training system based on false image projection.

FY-87 Phase I

Project Title: Post-Crash Aircraft Fuel Fed Fire Prevention

Principal Investigator: Michael R. Beltran

Company: Beltran, Inc.
1133 East 35th Street
Brooklyn, New York 11210

Contract Number: DTRS-57-87-C-00087

Period of Performance: 1 Oct 87 - 31 Mar 88

Technical Monitor: G. Klueg, ACD-220

Summary of Completed Research: Suppression and reduction of airplane crash fires remains a complicated process to describe and categorize. A crash scenario was developed which broke down into categories the four fuel emission processes that may occur during the various phases of the crash situation. The fuel emission processes were broken down into 1) misted fuel, 2) high speed emitted fuel, 3) low speed emitted fuel, and 4) internally flowing fuel. The potential benefits of various combinations of fuel modifications and ignition source suppression were evaluated. In the past, ignition source suppression has been shown to be effective. Fuel modification using antimisting additives (FM-9) has been shown to be an effective reducer of the mist fireball in both sub-scale and full-scale crash experiments. A major part of the work conducted in this project was to see if alternative fuel modification techniques are feasible and can be implemented. These alternative techniques would address other aspects of the fuel emission process in addition to the mist fireball. If these fuel modification processes could be tailored to reduce the impact of the four fuel emission processes and reduce their contributions to the development of the post-crash fire situation, significant safety margin increases could be realized. In Phase I, various means were evaluated to 1) prevent fuel spills from tanks, 2) reduce the flammability of fuel, 3) isolate the spilled fuel, and 4) reduce sources of ignition. A systems type approach was formulated to minimize the risk of cabin fire by controlling these four factors. This analysis was presented in a matrix format for ease in assessing various potential aircraft fire scenarios.

FY-87 Phase I

Project Title: Electronic Bomb Fuze Detection

Principal Investigator: James R. Ralston

Company: HDS, Inc.
12310 Pinecrest Road
Reston, Virginia 22091

Contract Number: DTRS-57-87-C-00092

Period of Performance: 1 Oct 87 - 1 April 88

Technical Monitor: R. Mason, ACT-360

Summary of Completed Research: This project was undertaken to determine the feasibility of providing transportation security personnel with an electronic aid in searching persons, luggage, and freight for explosive devices. Techniques were examined for detecting electronic components that may be incorporated in timing and triggering circuits. Four potential detection techniques were experimentally investigated. These were directed at detecting 1) the emissions and scattered signal modulation associated with running oscillators, and 2) the harmonic and intermodulation products that are generated when nonlinear electronic circuit components are illuminated by strong RF signals.

Based on the results, it is feasible to detect the presence of both active and inactive timer/oscillator circuits that may be present as part of a terrorist bomb. This conclusion is based on a careful investigation of several possible detection techniques applied to a wide variety of electronic fuze components. Although several means of detection were demonstrated to be effective, a particularly promising system concept was developed based upon a combination of two techniques: a passive very low frequency (VLF) receiving system (to detect activated oscillators), and a harmonic detection system (to respond to all electronic devices, active or not).

The next phase will be assessing the practical operational effectiveness and the impact of integrating the detection techniques into current security procedures. To accomplish this, it is necessary to develop and produce a number of marketable prototype units which can be efficiently used by current security personnel without imposing unrealistic training requirements.

FY-87 Phase I

Project Title: Simulation Model of Aircraft Evacuation Process

Principal Investigator: Barry S. Gourary

Company: Gourary Associates, Inc.
187 Gates Avenue, P. O. Box 1227
Montclair, New Jersey 07042

Contract Number: DTRS-57-87-C-00124

Period of Performance: 1 Oct 87 - 24 Mar 88

Technical Monitor: D. Chandler, AAM-119

Summary of Completed Research: This project studied the feasibility of using the personal computer to model the aircraft evacuation process. An experimental model was formulated. The model allows the study and visualization of passenger movement during evacuation. The model also permits the study of the effects of crowding, fire, obstructions, and other effects associated with the evacuation process. The model accounts for the collection of detailed passenger reactions to various perils in the cabin during evacuation, including closed doors and spreading flames. It is useful for comparison of aircraft designs, aircraft certification, and training of flight personnel. It will enable the collection of data on passenger escape strategies. The model runs on an IBM-PC or compatible computer. In its programmed form, it is intended to be "user friendly" and provide both a color CRT display and detailed hard copy printout.

FY-87 Phase I

Project Title: Integrated Fuselage Fire Detection and Monitoring System

Principal Investigator: Edward K. Budnick

Company: Hughes Associates, Inc.
2730 University Blvd. West, Suite 902
Wheaton, Maryland 20902

Contract Number: DTRS-57-86-C-00093

Period of Performance: 1 Oct 87 - 31 Mar 88

Technical Monitor: A. Abramowitz, ACT-350

Summary of Completed Project: This study was conducted to determine the feasibility of an integrated fuselage fire detection and monitoring system (IFFDMS) for use in inaccessible compartments onboard commercial aircraft. The study involved several tests, a literature review, selection and evaluation of candidate sensor technology, and development of a signal processing system.

Several line-type thermal sensors were evaluated from which a continuous thermocouple cable was selected as the candidate sensor. Small-scale testing and evaluation of the continuous-line thermocouple cable indicated that several key performance requirements may be achieved. The cable was capable of 1) providing continuous sensing and signal transmission, 2) providing location discrimination, and 3) continual upgrading of information on fire or overheat intensity and speed.

A companion effort involved development of a processor/verification subsystem. The subsystem provided the basic software-hardware design for "smart" detection capabilities.

Results indicated that the IFFDMS system designed in this study meets the initial feasibility requirements provided by the sponsor.

FY-87 Phase I

Project Title: Remote Passenger Baggage Identification

Principal Investigator: T. D. Geiszler

Company: Indala Corporation
1420 Knoll Circle, Suite B
San Jose, California 95112

Contract Number: DTRS-57-87-C-00095

Period of Performance: 1 Oct 87 - 31 Mar 88

Technical Monitor: R. Mason, ACD-360

Summary of Completed Research: The project proposed conducting research on the application of electrostatic proximity readers and tags to the problem of remotely and accurately identifying passenger baggage moving on a conveyor to permit automatic sorting, routing and baggage-passenger matching.

A portal was constructed which allowed mounting of various coil configurations and sizes for testing. Several electrostatic probes were mounted in the portal to receive signals from the tags as they were inserted into the portal at all points and in all orientations. Data transmitted from the tag was observed for strength and correctness on an oscilloscope and a liquid crystal display connected to the probes mounted within the portal. Tags were attached to objects including baggage of various sizes, shapes, and materials. The bags were also passed through the portal in various orientations as on a conveyor. Identification was again observed for correctness.

It was successfully demonstrated that electrostatic coupling of identification data from the tag attached to the baggage could be reliably and accurately read by the probes placed within the portal as luggage passed through the portal. The tag identification data was read when attached to objects of various sizes, shapes, and materials, including metal while being passed through the reader portal in any orientation.

Automatic identification of objects passing a reader can be used in industrial automation to route and track parts, materials, or finished goods. Additionally, when applied to baggage identification, it would allow efficient, accurate baggage-passenger matching, automated baggage sorting and routing, and aid in the recovery of misrouted baggage.

FY-87 Phase I

Project Title: Squid NMR for Explosives Detection

Principal Investigator: Ronald E. Sager

Company: Quantum Design, Inc.
11578 Sorrento Valley Road, State 30
San Diego, California 92121

Contract Number: DTRS-57-87-C-00009

Period of Performance: 1 Oct 87 - 12 Aug 88

Technical Monitor: C. Seher, ACD-360

Summary of Completed Research: This program was initiated to investigate the potential application of Superconducting Quantum Interference Devices Nuclear Magnetic Resonance (SQUID NMR) detection technology to the solution of explosives detection problems. The research focused on detecting sheet explosives concealed in airline baggage. A number of conclusions were drawn from the study.

First, SQUID detection of NMR signals is difficult but feasible. A SQUID NMR detection system utilizing surface coils will possess the sensitivity required to detect sheet explosives concealed in the sides of suitcases and other airline baggage. Based on NMR measurements made on PETN (an explosive) during the project, a low false alarm rate (less than 1 percent) and high throughput rate (greater than 20 bags/minute) should be possible. By employing surface coils and immersing the entire bag in the magnetic field, the required field strength can be made quite low (220 Gauss). This field level will not damage magnetic media such as computer discs or audio and video tape.

The detection system configuration while unusual does not pose any new or serious problems in terms of cryogenic engineering. The steady magnetic field required could be produced by conventional means or by the new high temperature superconducting wire when available. The latter, by employing only liquid nitrogen refrigerant would greatly simplify the refrigeration system.

FY-87 Phase I

Project Title: Workload Assessment Technologies for the Optimization of Data Link Controller Procedures

Principal Investigator: Clark A. Shingledecker Ph.D.

Company: NTI, Incorporated
Suite 235, 4130 Linden Avenue
Dayton, Ohio 45432

Contract Number: DTRS-57-87-C-00098

Period of Performance: 1 Oct 87 - 18 Mar 88

Technical Monitor: N. Talotta, ACD-320

Summary of Completed Research: The Mode S data link, under development by the FAA, is an essential upgrade to the existing air traffic control (ATC) system. In order to insure the improvements in safety and efficiency of ATC services mediated by this data link, it will be necessary to assess its effects on the workload and performance capabilities of air traffic controllers.

Phase I developed the methodological tools required to identify potential workload problems associated with data link functions and evaluated the impact of system design and procedures on controller performance and workload. As a result of the research completed, NTI identified primary workload issues associated with implementing the initial package of three data link ATC services. In addition, they specified workload and performance metrics for assessing the effects of procedural and design options on controllers. Empirical methods were developed for testing these alternatives in a series of part task and full-scale, controller-in-the loop simulation studies. NTI documented the study in the form of a comprehensive test plan for controller evaluation of the data link ATC services.

This research produced a workload and performance assessment methodology. When implemented and validated it can be employed in the design and evaluation of a broad range of future ATC improvements. Futhermore, standardized versions of these methods will apply to human factors design problems in a variety of other highly automated systems emerging in manufacturing, process control, and transportation industries.

FY-87 Phase I

Project Title: Weapon Image Introduction to X-Ray Baggage Scans

Principal Investigator: William Redmann

Company: Muenter, Redmann & Associates
4564 Los Angeles Avenue, Unit D
Simi Valley, CA 93063

Contract Number: DTRS-57-87-C-00099

Period of Performance: 1 Oct 87 - 28 Mar 88

Technical Monitor: L. Malotky, ACS-210

Summary of Completed Research: This project proposed development of a device to superimpose stored weapon images onto x-ray scans of baggage in airports. Such a device would favorably enhance security guard alertness and motivation at airport x-ray checkpoints. Phase I research answered two primary questions. First, achieving an acceptable image derived from the combination of a live baggage scan and a stored weapon image is feasible. Second, performing this in real-time while working only with the video signal.

First, it was demonstrated that an acceptable overlay of a weapon can be performed. Algorithms for this were derived from primary data. The algorithms produced results substantially indistinguishable from the real thing in side-by-side comparisons by experts. These experiments are shown to be valid for all popular scintillator-based, baggage x-ray systems in use in the United States and Europe. The methods used can accommodate the many viewing modes found in those systems.

Second, a preliminary design for hardware implementation was prepared. This design meets the basic functional criteria by having the capability to execute in real time the algorithms demonstrated. Beyond this, the design uses a general purpose microcomputer which is also available to provide a versatile interface for bookkeeping activities, enhancing the utility of the device.

FY-87 Phase I

Project Title: Computer Voice and Speech Data Entry and Recognition

Principal Investigator: Dr. Philip Shinn

Company: Speech Systems, Inc.
18356 Oxnard Street
Tarzana, California 91356

Contract Number: DTRS-57-87-C-00016

Period of Performance: 8 Feb 88 - 8 Aug 88

Technical Monitor: G. Booth, ADS-120

Summary of Completed Research: The advent of computerized air traffic control systems has created a need for an effective man-machine dialogue not encumbered by excessive keyboard interactions. A real-time, continuous speech interface may be applicable. Until now, speech-recognition technologies have not found application in the air traffic control environment. The goal of this project was to demonstrate the use of a speech recognition system in air traffic control. This was accomplished by interfacing Speech Systems' speaker-independent, continuous speech recognition system with the Air Traffic Controller ATC Coach expert system developed by UFA of Newton, MA. Syntaxes were developed, interface code written, dictionary entries created and tested, and problems debugged in order to perform the demonstration of the combined systems working in tandem. The research and development focused on three principal areas: 1) the construction of machine grammars, 2) building the interface hardware and software between the UFA Apollo and the Speech Systems SUN computers, and 3) fine tuning the ATC Dictionary and codebook for automated recognition.

The demonstration was conducted successfully in August of 1988. Recognition accuracy was above the 98 percent range. A video tape of the demonstration was made and is available from the FAA SBIR Office.

FY-87 Phase I

Project Title: X-Ray False Image Projection

Principal Investigator: Stanley Hack

Company: TAU Corporation
485 Alberto Way, Building D
Los Gatos, California 95032

Contract Number: DTRS-57-87-C-00102

Period of Performance: 1 Oct 87 - 31 Mar 88

Technical Monitor: L. Malotky, ACS-210

Summary of Completed Research: Algorithms were developed, implemented, and tested to provide false image projections of threat weapon images acquired and displayed by airport hand baggage x-ray security systems. Using an image processing laboratory environment and video taped x-ray images of hand baggage and threat weapons, TAU successfully proved the feasibility of a system with such capabilities. The tasks successfully completed during the Phase I effort were: 1) constructing a test image database, 2) segmenting hand baggage from the video field of view, 3) locating the interior space of the hand baggage that was segmented from the video field of view, 4) placing the threat weapon image in the hand baggage image at various orientations to simulate various detection difficulty levels, and 5) merging the threat weapon image with the hand baggage image in an artifact-free manner.

The development described will result in a low-cost, add-on processor to be used in conjunction with presently deployed airport concourse security x-ray screening systems to measure operator performance and to provide positive motivation by the detection of simulated threat weapons.

FY-86 Phase II

Project Title: Test Methods to Determine the Degree of Asphalt Stripping from Aggregates

Principal Investigator: Patrick B. Kelly

Company: Kelly/Strazer Associates, Inc.
1630 Southwest Morrison Street
Portland, Oregon 97205

and

H & V Materials Research and Development
3187 Northwest Seneca Place
Corvallis Oregon 97330

Contract Number: DTRS-57-86-C-00124

Period of Performance: 15 Oct 86 -

Technical Monitor: H. Tomita, ADS-240

Summary of Proposed Research: Moisture-induced damage to asphalt pavement related to stripping of asphalt cement from aggregates or softening of asphalt cement has produced serious distress, reduced performance, and increased maintenance of pavements throughout the United States. Under a Phase I SBIR project, an index of retained resilient modulus (IRM_r) was successfully employed to 1) determine the susceptibility of a mix to asphalt stripping and softening of the asphalt cement in the presence of water, and 2) evaluate the use of additives to overcome the tendency for moisture-induced damage of asphalt concrete. The IRM_r was determined with prototype diametral repeated load test equipment and test procedures. The implications of many test and material condition parameters on the IRM_r could not be fully explored. Under the Phase II effort 1) the repeated load diametral test equipment will be made more "user friendly" by adding digital readout together with improved data acquisition techniques, 2) the test methods and conditioning procedures will be thoroughly investigated and standardized, and 3) the IRMr will be related to the field performance of pavements experiencing moisture-induced damage to insure that test equipment and procedures will be accepted by the pavement engineering profession.

Anticipated Results: Consulting civil engineers, material testing companies, and all federal, state, and local agencies concerned with paving materials for airports and roads would have use for the test equipment and associated procedures.

FY-86 Phase II

Project Title: Infrared Ice Accretion Measurement System

Principal Investigator: Abbas M. Sinnar, Ph.D.

Company: Sinnar Assoc.
6111 Triangle Drive
Columbia, MD 21044

Contract Number: DTRS-57-86-C-00126

Period of Performance: 6 Oct 86 - 28 April 89

Technical Monitor: S. Agrawal, ACD-110

Summary of Completed Research: Remote runway surface condition sensors that could detect ice onset and monitor its rate of accretion on airport operational surfaces would enhance runway safety while reducing airport equipment, manpower, and chemical costs. The main objective of this two-phase research, sponsored by the FAA SBIR program, was to determine, in Phase I, the feasibility of the proposed infrared ice accrection measurement system using a laboratory breadboard experimental setup to and to develop, in Phase II, a prototype system with computerized data acquisition/analysis capability.

During Phase I research, absorption coefficients of ice, water, and deicing fluids (UCAR RDF and Glycol-Water solution) were determined between 1 and 2 um wavelengths. Icing-deicing and Frosting-defrosting tests, wherein, transmittance measurements were made at 1.42 and 1.56 um wavelengths, demonstrated that the prototype technique can be employed to determine icing onset, to monitor the status of icing/deicing process and to measure the frost thickness.

The Phase II Research program encompasses development of a system, wherein, a source radiation is directed to one or more distant icing monitoring sites, to be reflected back to the source location for detection and analysis. A micro-computer based system performs performs real time data acquisition/analysis and displays icing and water layer thickness.

The potential application of this R&D effort lies in the commercial development of airport and aircraft based systems to determine the onset, duration, accumulation and dissollution of icing on airport runways, navigation aid structures and on aircraft.

Project Title: Adhesive Materials for Sealing Conductors and Light Units in Airport Pavements

Principal Investigator: Roy A. White

Company: Springborn Laboratories, Inc.
10 Springborn Center
Enfield, Connecticut 06082

Contract Number: DTRS-57-86-C-00127

Period of Performance: 10 Oct 86 -

Technical Monitor: A. McLaughlin, ADS-240

Summary of Proposed Research: Field failures of wires imbedded in saw kerfs with various sealants/adhesives and also embedded runway light units entailed breaking loose, softened asphalt adjacent to the adhesive and cracks in the asphalt parallel to the saw kerf. Phase I research indicated some sand filling epoxies exceed the modulus of bituminous concrete. This would encourage breaking loose and cracks in the bituminous. There was a large coefficient of expansion mismatch between the sealants used and bituminous concrete which would encourage breaking loose. Research indicated that high loadings of tiny glass beads could largely overcome the expansion mismatch. It was found that ingredients in polyesters and some epoxies soften or even dissolve the asphalt. Moist surfaces cause adhesion problems. It was also found that polysulfides, urethane, silicones, and hot melts could be used as sealants--if formulated correctly. The concept of filling the saw kerfs with a shaped foam was partially developed. Phase II research is attempting to develop nonbituminous-attacking, low-thermal expansion epoxy, polyester, hot melt, polysulfide, urethane, silicone sealant systems. The polysulfides, urethane, and silicone materials may also be developed into one-part systems. Additionally, development of a foam-filled kerf, and new tests and changes in P-606 specifications will be undertaken.

Anticipated Results: The development of a number of sealant/adhesives for runway work superior to those currently in use is anticipated. This is particularly true of one-part systems currently under development. Additional applications would be in the area of general construction--floor surfacing and patching, concrete crack repair, caulking-sealants, cast and bituminous concrete joint filling, street and highway traffic loops, etc.

FY-86 Phase II

Project Title: Computer Aided Reasoning Technology

Principal Investigator: Arthur Gerstenfeld

Company: UFA, Inc
710 Commonwealth Avenue
Newton, Massachusetts 02159

Contract Number: DTRS-57-86-C-00119
DTRS-57-87-C-00103 (expansion of original contractual effort)

Period of Performance: 10 Oct 86 -

Technical Monitor: A. Adkins, ACD-340 (original)
G. Booth, ADS-120 (expanded effort)

Summary of Proposed Research: Consistent with the increasing application of Artificial Intelligence to "expert systems" for education and training, this project intends to produce an Intelligent Tutoring System to assist training development of air traffic control (ATC) personnel. This system is named ATC Coach. The project consists of six objectives to be completed over a two year period. The first objective is to build a preliminary prototype. This equipment will include both DEC Microvax and Symbolics computers programmed in C and Common LISP, respectively. The second objective is to rearrange the overall structure of the prototype and add rules to the database. The third objective is to add speech recognition and generation capability to the system. The fourth objective is to test the system with actual users and to revise the system as necessary. The fifth objective is to port the system to hardware to be used in the field. (Within this objective training for FAA controller personnel on system use will be accomplished). The final objective will be to establish a means for updating the system. The system will be installed at Logan Airport for field trials.

Summary of Research Completed to Date: The prototype hardware and software have been developed. Speech recognition and generation capability have been added. This entailed integrating commercial systems from DEC and Dragon Systems. DECtalk is used for speech output and a COMPAC PC is interfaced to the Microvax to afford speech recognition capabilities. The system is currently being tested and revised at Logan Airport.

Anticipated Results: When completed this project will be able to demonstrate the feasibility of an intelligent tutoring system for training air traffic controllers.

FY-86 Phase I

Project Title: Intelligent Warning and Emergency Procedures System Feasibility Study

Principal Investigator: Sol Kaufman

Company: Analysis and Simulation, Inc.
One American Drive
Buffalo, New York 14225

Contract Number: DTRS-57-86-C-00094

Period of Performance: 6 Oct 86 - 6 Apr 87

Technical Monitor: R. Guishard, ACN-210

Summary of Completed Project: Analysis of National Transportation Safety Board accident briefs confirmed the high frequency of monitoring and procedural pilot errors. It identified the major abnormal conditions that are potentially detectable through automatic sensor monitoring. The availability and accessibility of various sensors on general aviation aircraft were assessed and tabulated. Recent literature on artificial intelligence applications in a cockpit environment was reviewed. Although most papers dealt with conceptual systems in relatively sophisticated military or commercial airplane environments, they helped clarify specific techniques and basic reasoning architecture for a real-time system.

The concept of an Intelligent Warning and Emergency Procedure System (IWEPS) emerged as a real-time single board microprocessor which samples and reasons from a set of sensor inputs. If an abnormal condition is detected, IWEPS would alert and advise via visual and aural messages. The IWEPS concept was augmented to include presentation of stored checklists and execution of various standard calculations on pilot request. These functions will contribute to reduced pilot workload and safety enhancements. The technical feasibility of this total IWEPS concept, including sensor and pilot interfaces, was assessed, and a realistic four-stage computer/system development program was formulated. A problem noted was incomplete sensor availability in many aircraft and costs associated with achieving the necessary interface. In order to make some of IWEPS' capabilities available to the broadest possible segment, a core version emphasizing just checklist recall and user-friendly standard calculations was postulated. An illustrative rule-base was formulated aimed at keeping track automatically of the current phase of airplane flight and assisting the pilot in fuel system management.

FY-86 Phase I

Project Title: Attenuation of Fire Radiation Through Water Sprays or Fog

Principal Investigator: Michael R. Beltran

Company: Beltran Inc.
1133 East 35th Street
Brooklyn, New York 11210

Contract Number: DTRS-57-86-C-00098

Period of Performance: 1 Oct 86 - 31 Mar 87

Technical Monitor: T. Eklund, ACD-240

Summary of Completed Project: Fuel-spill, post-crash cabin fires account for 40 percent of the fatalities occurring in aircraft accidents, the main cause being radiation, smoke, and other toxic gases. The research program identified and formulated the processes involved in fire attenuation. Although radiation was the most dominant mode of heat transfer in the presence of a convective medium, the heat transfer coefficient and hence, convective heat transfer increased rapidly. Based on the various processes, a model with the necessary governing equations was developed; a simplified version, taking into account only the droplet attenuation, was solved numerically. Experimental techniques to verify and augment the analytical work were outlined.

The optimum droplet radius was found to be approximately equal to the wavelength of the radiation. For fuel fires, the optimum radius is about two microns. Much larger drops can also be used with the same effect, but they require more water. However, drops greater than 200 microns radius do not produce significant attenuation. Current sprinkler systems produce very large drops (500-5000 microns) and, as such, are ineffective in attenuating IR radiation.

Project Title: An MLS Based Low-Cost High-Accuracy Terminal Area Navigation System

Principal Investigator: Alper K. Caglayan

Company: Charles River Analytics, Inc.
55 Wheeler Street
Cambridge, Massachusetts 02138

Contract Number: DTRS-57-86-C-00099

Period of Performance: 1 Oct 86 - 1 April 87

Technical Monitor: J. Remer, ACL-1

Summary of Completed Project: This study investigated the feasibility of developing a microwave landing system (MLS) based low-cost, terminal area navigation system. The system blended onboard sensor measurements with MLS data by using generally available attitude sensors. The study showed the feasibility of building such an MLS based, low-cost terminal area navigation system which provides not only highly accurate aircraft inertial position and velocity estimates but also wind estimates. The developed MLS navigation filter blended flight control quality accelerometer measurements with MLS data by using attitude information from vertical gyro/directional gyro based attitude indicators.

Two navigation filter structures were examined in the study. The first was a complementary filter using MLS pseudomeasurements computed by an MLS reconstruction algorithm. The second one was an extended Kalman filter processing that the MLS sensor measurements directly. Results obtained on the six-degree-of-freedom nonlinear simulation of a commercial transport in an MLS environment showed that both navigation filters exhibit excellent estimation performance. The study also derived and validated a reconstruction error prediction algorithm for the MLS reconstruction algorithm employed in the complementary navigation filter.

FY-86 Phase I

Project Title: Methodology for Correlation of ATC Controller Workload and Errors

Principal Investigator: Elizabeth D. Murphy

Company: Computer Technology Associates, Inc.
5670 Greenwood Plaza Blvd., Suite 200
Englewood, Colorado 80111

Contract Number: DTRS-57-86-C-00101

Period of Performance: 1 Oct 86 - 31 Mar 87

Technical Monitor: E. Pickrel, AAM-500

Summary of Completed Project: The research studied the feasibility of quantifying the effects of increased automation on the workload and performance of air traffic controllers. The research focused on adapting a human performance model to represent the controller's job in the AAS/AERA 2 environment. As a result, the research developed a controller performance model (CPM). The adapted model included 1) a functional hierarchy representing levels of human interaction with automated capabilities, 2) an attribute hierarchy representing dependencies between functional levels, and 3) a set of computational procedures for aggregating attribute values from lower to higher levels of the model's "tree" structure. Controller error is incorporated within the model as a function of the relationships between demands on the controller's attention resources, available skills, and motivational aspects of the controller's job. A unique feature of the CPM is that it supports prediction of performance at any point after task element demands have been quantified.

FY-86 Phase I

Project Title: Vapor Desorption Enhancement System

Principal Investigator: Charles E. Brossia

Company: First Omega Group, Inc.
10205 West Exposition Ave.
Lakewood, Colorado 80226

Contract Number: DTRS-57-86-C-00104

Period of Performance: 1 Oct 86 - 1 Apr 87

Technical Monitor: W. Wall, ACD-120

Summary of Completed Project: The desorption of both model explosive and actual explosive vapors may be enhanced as the result of applied electromagnetic radiation. It was proven that the infrared portion of the electromagnetic spectrum was the most efficacious of the various wavelength bands tested. Experimentation also proved the existence of certain fundamental bands within the IR spectrum which were more successful at enhancing desorption than the rest of the spectrum combined. The infrared spectrum's ability to cause desorption and the ability to narrow the spectrum to a few specific wavelength bands was thought to arise from the chemical composition of the fabric samples rather than from the composition of the commonly worn fabrics. It appeared as though only a few wavelength bands would be needed to enhance the desorption of all types of explosive vapors. A theoretical model was presented which explained the infrared spectrum efficacy.

From the results of this experimentation it appeared that a new type of apparatus could be constructed which would greatly increase the desorption of explosive vapors. Enhancements of 1000 percent over the desorption experienced under natural conditions were expected with further optimization of the experimental parameters.

Project Title: Development of a Fog Generator for Attenuation of Fire Radiation

Principal Investigator: G. Stuart Knoke

Company: Flow Research Company
214414 68th Avenue South
Kent, Washington 98032

Contract Number: DTRS-57-86-C-00105

Period of Performance: 1 Oct 86 - 31 Mar 87

Technical Monitor: T. Eklund, ACD-240

Summary of Completed Project: This project investigated and evaluated the feasibility of developing a water generator to control mass transportation passenger vehicle fires by attenuating heat transfer. The purpose of attenuating the infrared fire radiation from the flame was to eliminate ignition of cold surfaces near the fire, thereby stopping the spread of the fire. The research was carried out in four tasks. The first was a numerical analysis of radiation absorption using computer codes. The effective blockage of the fire radiation by the water fog was calculated as a function of relevant fire and fog parameters, such as the particle diameter, the radiation wavelength, and the particle's complex index of refraction. For the second task, an experiment was designed to demonstrate the absorption of the fog utilizing a radiation source, a radiation detector, and a fog nozzle. During the third task, a test apparatus was constructed and a variety of radiation attenuation tests were performed. The last task determined the operating parameters for a fog generator system based on test results obtained in task three.

The findings of the numerical analysis showed that to accomplish a 90 percent blockage, a fog layer with a mass loading of about 20 g/m^2 interposed between the fire and the receiver is required if the water droplet diameters are in the range of two to three micrometers. The results of the laboratory experiments indicated that radiation attenuations were consistent with the numerical analysis. Extinction coefficients of $4m^{-1}$ and more were easily obtained with the Saracco nozzles. With an extinction coefficient of 4 m^{-1}, the fire radiation intensity is attenuated by a factor of 55 in each meter of fog. Based on the development of a Saracco nozzle for cabin application, about 200 such nozzles would be required to operate for one minute to completely fill a large passenger cabin with a dense fog, using about three gallons of water.

FY-86 Phase I

Project Title: Laboratory Investigation of Atmospheric Effects on Vortex Wakes

Principal Investigator: H. T. Liu

Company: Flow Research Company
214414 68th Avenue South
Kent, Washington 98032

Contract Number: DTRS-57-86-C-00106

Period of Performance: 1 Oct 86 - 31 Mar 87

Technical Monitor: P. Massoglia, AES-320

Summary of Completed Project: Tow tank experiments were successfully conducted to demonstrate the feasibility of investigating atmospheric effects on the evolution of a trailing vortex wake. The vortex wake was generated by a towed NACA 0012 wing or a specially designed 2-D vortex generator. Atmospheric disturbances simulated in the tank included stable stratification, ambient turbulence, and wind shear. Visualizations of the vortex wakes from several perspectives were conducted using fluorescent dye illuminated by bands of ultra-violet lights and a sheet of laser light. Qualitative and quantitative information established the upper bound of the lifespan of a trailing vortex wake due to essentially self-induced sinusoidal instability. Ambient turbulence reduces the lifespan. Vortex linking is the dominant mode of vortex instability in weak turbulence. As the turbulence intensity increases, vortex bursting begins to appear and eventually replaces linking as the dominant mode of instability. In a weak stable environment, detrainment of fluid from the vortex oval into the ambient was clearly observed for the 2-D vortex, although the trailing vortex wake was not as dramatic. The detrainment reduces the vortex separation and speeds up the vortex descent. Relatively weak shear effects can be observed when the ambient turbulence is suppressed by a weak stratification.

Wind shear affects the vortex in two ways. In a longitudinal shear, the inclined trailing vortex pair is stretched, resulting in contraction, speed of descent, and possibly annihilation prior to the onset of linking or bursting. In a cross shear, the vortex wake is forced to rotate about its axis. In the extreme situation, the wake rotates 180 degrees and reverses its course from descending to ascending. Finally, the swirl components of vortex wakes derived from time-lapse photographs of the microcapsule show great promise in mapping out the entire vortex flow field.

FY-86 Phase I

Project Title: Advanced Techniques for Detection of Plastic Weapons

Principal Investigator: William Jacobs

Company: J V W Electronics, Inc.
1945 Techny Road
Northbrook, Illinois 60062

Contract Number: DTRS-57-86-C-00121

Period of Performance: 6 Oct 86 - 8 Apr 87

Technical Monitor: D. Riley, ACD-120

Summary of Completed Project: The purpose of this research was to determine if Nuclear Magnetic Resonance (NMR) technology could be used to detect concealed plastic weapons in carry on luggage at airports. NMR and infrared spectrometry analysis were run on a series of eight materials including the Glock 17 pistol, an Olin flare pistol, a plastic knife, two typical plastics found in hand-carried luggage (for comparison purposes), gasoline, alcohol, and tear gas.

The tests showed that NMR and IR signatures of the two pistols, the knife, and the three liquids generated spectra that are very similar to many common materials carried in hand luggage. For example, the plastic knife has a spectral content similar to the nylon found in combs and hairbrushes; the olin flare pistol has a spectrum similar to the plastic materials used to fabricate luggage, and the liquids have signatures similar to liquor/cologne and very dissimilar to high explosives. Significant improvements to the existing NMR system for detecting plastic explosives are possible, and new types of NMR using "SQUID" detectors are possible. Questions remain on how "SQUID" detectors would react in the presence of metal in the detection space.

Project Title: Sensors for the Detection of Non-Metallic Weapons Concealed upon Personnel

Principal Investigator: Lawrence E. Larsen

Company: Medical Microwave Research Corp.
808 Pershing Drive, Suite 104
Silver Spring, Maryland 20910

Contract Number: DTRS-57-86-C-00107

Period of Performance: 6 Oct 86 - 4 Apr 87

Technical Monitor: D. Riley, ACD-120

Summary of Completed Project: The project had as a goal the detection of non-metallic materials that may be weapons or weapon components, such as plastic guns or plastic explosives, when they are concealed under clothing worn by people. The proposed method was based on detection of emissivity contrast between nearby skin and concealed plastic. Passive millimeter wave sensors were designed for minimal susceptibility to electromagnetic interference. The sensor was tested with various materials against simulated skin with and without fabric covers in an electromagnetic scanner. Linear scan rates were 14 mm/sec. The results showed detection of plastic, such as nylon and glass reinforced plastic composite, with a signal-to-noise ratio of better than 10 dB. Furthermore, material differences were shown among members of the plastics class, as well as between plastics as a class and metal. Leather wallets and belts were not detected. Eight fabric covers were tested that ranged from thin tricot to three-layered quilting and heavy wool. None of the materials had a substantial effect on the performance of the sensor.

FY-86 Phase I

Project Title: Effects of Stratification and Wind Shear on the Evolution of Aircraft Wake Vortices Near the Ground

Principal Investigator: Donald P. Delisi

Company: Northwest Research Associates, Inc.
300 120th Avenue NE, P. O. Box 3027
Building 7, Suite 220
Bellevue, Washington 98009

Contract Number: DTRS-57-86-C-00108

Period of Performance: 6 Oct 86 - 6 Apr 87

Technical Monitor: P. Massoglia, AES-320

Summary of Completed Project: This effort studied how stratification and shear effect the evolution of aircraft trailing-tip vortices as they approach the ground and how they evolve when they are generated near the ground. The study incorporated laboratory experiments and concurrent numerical modeling. It matched model Froude numbers and shear parameters with their full-scale values.

Results indicated that stratification and shear can have significant effects on the evolution of the vortex system. In nonstratified, nonshear flow, vortex evolution was symmetric; each vortex decayed at the same rate. Adding stratification maintained the symmetry but inhibited the vertical migration. In ground effect, stratification also inhibited horizontal migration and cancelled the rebound effect (observed in the nonstratified, nonshear case). In a nonstratified flow with shear, vortex evolution was asymmetric. In ground effect, the shear also acted to severely reduce the rebound effect. With stratification and shear (Richardson number equal to one) and in ground effect, the flow was asymmetric and two effects were observed. When the vortex pair was weak, relative to the shear (strong crosswind condition), the weaker downwind vortex was closer to the ground than the stronger upwind vortex. (If the vortex pair was far from the ground, a solitary vortex developed). If the vortex was stronger relative to the shear (weak crosswind conditions), the weaker downwind vortex would be further from the ground than the stronger upwind vortex. In either case, the vortices may migrate far from their initial generation position.

FY-86 Phase I

Project Title: Airborne Wind Shear Sensor Research

Principal Investigator: Todd A. Cerni

Company: OPTIR Corp.
7333 West Jefferson Ave., #210
Lakewood, Colorado 80235

Contract Number: DTRS-57-86-C-00109

Period of Performance: 10 Oct 86 - 10 Apr 87

Technical Monitor: J. Reed, ACD-230

Summary of Completed Project: This project demonstrated the feasibility of an airborne forward-looking low-level wind shear sensor based on a Doppler lidar. Microbursts are the primary cause of the low-level wind shear aviation hazard. Microbursts are small in size (1 to 3 km in diameter) and very short lived (1 to 3 min duration), making them very difficult to detect with conventional sensors. They can cause headwind/tailwind couplets to form along the flight path which can be very hazardous to commercial aircraft both on approach to landing as well as during and shortly after takeoff. Dry microbursts occur when the precipitation falling from cloud base evaporates before reaching the ground, and wet microbursts are those which bring rain to the ground. Of all proposed low level wind shear sensor systems, only the Terminal Doppler Weather Radar (TDWR) ground-based Doppler radar and the airborne forward-looking sensors could reliably provide the aircraft flight crew with advanced warning of a low level wind shear hazard. The disadvantages of the TDWR are cost and their questionable performance in dry microbursts. Only airborne forward-looking sensors have the promise of supplying the flight crew with real-time, continuous wind measurements in the aircraft flight path.

Doppler radars and Doppler lidars constitute the only practical options for airborne forward-looking wind measurement sensors. Airborne Doppler radars perform well in wet microbursts, but they are not able to consistently detect dry microbursts. Airborne Doppler lidars perform very well in dry microbursts. While their performance in heavy rain is reduced, it is still adequate. Numerical modeling predications indicate the proposed airborne Doppler lidar would have a range of 2 to 5 km for dry microbursts and 1 to 3 km in heavy rain. The proposed airborne Doppler lidar would be of modest size, weight, and power consumption.

FY-86 Phase I

Project Title: Non-Destructive Evaluation Technique Using Laser Shearography

Principal Investigator: Joanna Jannson

Company: Physical Optics Corp.
2545 West 237th Street, Suite A
Torrance, California 90505

Contract Number: DTRS-57-86-C-00110

Period of Performance: 1 Oct 86 - 30 Mar 87

Technical Monitor: L. Neri, ACD-220

Summary of Completed Project: The objective of the program was to investigate and demonstrate the application of a new optical nondestructive testing (NDT) technique based on the concept of shearography. Shearography, although bearing similarities to holographic interferometry, has essential inherent differences which make it a superior method of non-destructive testing in a practical, industrial environment. In addition to the advantages offered by optical testing methods in general, shearography does not require the system complexity and stringent stability necessitated by holographic interferometry. In addition, shearography produces a direct method of observing gradients rather than displacements and therefore enables observations and measurements on certain features; e.g., cracks, which are not inherently obvious in holographic nondestructive testing.

During Phase I research the feasibility of shearography as a practical tool for surface testing of defects was demonstrated. In addition, several new practical designs were developed including electronic and electro-optical media for recording defect patterns. The theoretical analysis and modeling of the technique were extended beyond the current state of understanding.

FY-86 Phase I

Project Title: Radiant Panel Test for Aircraft Composite Structures

Principal Investigator: Sami Atallah

Company: Risk & Industrial Safety Consultants
7151 West Gunnison, Suite 103
Chicago, Illinois 60656

Contract Number: DTRS-57-86-C-00111

Period of Performance: 1 Oct 86 - 31 Mar 87

Technical Monitor: C. Sarkos, ACD-240

Summary of Completed Project: This study examined the feasibility of developing a test apparatus and procedures that could be used to determine the manner of, and time to failure of, composite aircraft walls and construction materials. A gas fired radiant panel, approximately 4 by 4 ft was designed and constructed. The panel was capable of emitting up to 40,000 BTU/ft2 per hour at the surface. Different radiation levels could be achieved by varying the distance between the panel and the test object. Test sections measuring 1.5 by 1.0 ft were prepared from flat stock supplied by the FAA. Three composites were tested: Phenolic/Graphite, Phenolic/Glass, and Phenolic/ Kevlar. The bottom edge of each test section was applied to the top edge. Deformation of the upper edge was measured using a proximeter. Temperatures were recorded at four locations in each test section and at the radiant panel.

Comparison of the times-to-failure at similar exposure levels showed that Phenolic/Graphite was better than Phenolic/Glass and Phenolic/Kevlar, in that order. The latter was totally and irreversibly deformed at relatively low levels of radiation. The presence and location of restraints (e.g., bolts), and the magnitude of the applied load had a marked effect on the results.

FY-86 Phase I

Project Title: An Expert System to Aid Pilots of General Aviation Aircraft

Principal Investigator: Arthur Gerstenfeld

Company: UFA, Inc.
335 Boylston Street
Newton, Massachusetts 02159

Contract Number: DTRS-57-86-C-00119

Period of Performance: 1 Oct 86 - 1 Mar 87

Technical Monitor: G. Hetrich, ACD-340

Summary of Completed Project: The purpose of this study was to show the feasibility of having a general aviation device to aid pilot decision-making. The project developed a small, inexpensive system, a self-contained handheld pilot alert and recover device (SHEPHARD). This computerized system, written in a highly efficient computer language (C) informed the pilot where alternate airports were in case of an emergency landing. The system also aided the pilot in the event of his/her becoming lost, engine failure, or fire. Finally, the project demonstrated the feasibility of voice output for warnings or advice to be delivered to the pilot.

Project Title: Laser Generated Surface Acoustic Waves for Flaw Detection in Transportation Systems

Principal Investigator: Russell J. Churchill

Company: American Research Corporation of Virginia
P. O. Box 3406
Radford, Virginia 24143-3406

Contract Number: DTRS-57-85-C-00132

Period of Performance: 1 Oct 85 - 31 Mar 88

Technical Monitor: L. Neri, ACD-220

Summary of Completed Project: Transportation systems studies require in-service inspection using nondestructive evaluation (NDE) techniques for flaw detection and characterization. The structures to be tested are often inaccessible to conventional inspection techniques and situated in hostile environments. Despite efforts made during design and manufacturing to inspect for and reduce the number of defects and welds in structural components, NDE techniques are required for in-service monitoring of structural integrity in order to forestall component failure. The purpose of the Phase II program has been to investigate laser generation of ultrasound combined with laser interferometric detection for noncontact NDE of transportation components. The technical objectives included 1) extension of laser/solid interaction theory, 2) evaluation of heterodyne systems for detection of surface displacements, 3) determination of parameters for fiber optic heterodyne detection of laser-induced ultrasound, 4) development of signal processing techniques, 5) design of prototype systems, and 6) acquisition of families of test data and design and optimization of a proof-of-concept system for commercial applications. The principal findings of the Phase II program include the ability to detect simulated flaws using laser-generated ultrasound combined with interferometric detection. Laser ultrasonic signatures of defects allowed detection of flaws as small as 0.5mm. Additional results included the demonstration of optical fiber waveguides, use of fiber optic homodyne interferometry to detect surface acoustic waves, and development of signal processing techniques and data acquisition systems for digitizing and storing data.

Project Title: Unified Wake Analysis

Principal Investigator: Alan J. Bilanin

Company: Continuum Dynamics, Inc.
P. O. Box 3073
Princeton, New Jersey 08543

Contract Number: DTRS-57-85-C-00134

Period of Performance: 1 Oct 85 - 31 Mar 88

Technical Monitor: John O'Neill , ACD-130

Summary of Completed Research: This research effort was conducted under a cost-sharing arrangement between the Federal Aviation Administration and the Research and Special Projects Administration. Landing and takeoff delays at national metropolitan airports are now commonplace, especially during morning and early evening rush hours. These delays result primarily as a consequence of separation standards which have been established as a result of wake vortex concerns. The Phase I study concluded that it is currently possible and practical to develop a computer design tool capable of assessing wake intensity for existing and future jetliners.

Under Phase II a unified vortex wake predictive model, CDI-UNIWAKE was developed. It uses state-of-the-art numerical techniques to evaluate the vortex wake intensity behind current and future jetliners. This code runs on the Digital VAX series of computers under the VMS operating system. This technology incorporates the wake mitigating effects of propulsion wash, profile drag and atmospheric turbulence diffusion. The software does not introduce any new physics into understanding the dynamics of the evolution and decay of aircraft vortex wakes. It assembles known technologies to provide a software product which is reliable, accurate, and cost effective. This computer code should permit the direct comparison of the wake intensity between jetliners operating under simulated identical conditions This is a situation never achieved in the field and therefore, the source of much uncertainty in the interpretation of field data.

FY-85 Phase II

Project Title: Further Development of the Slaved Tandem Freewing Airplane Configuration

Principal Investigator: Edward H. Allen

Company: Daedalus Research, Inc.
Route 4, Airport Park
Box 327A1
Petersburg, Virginia 23803

Contract Number: DTRS-57-85-C-0133

Period of Performance: 1 Oct 85 - 30 Oct 87

Technical Monitor: J. Traybar, ACD-230

Summary of Completed Project: The project's two primary objectives were to further develop the technology base for the Slaved Tandem Freewing (STF) Airplance and to design a commercializable prototype aircraft for the civilian aviation marektplace. During the project four distinct test configurations were designed, built, and flight tested. The last was a verification test article for the final product, the STOL Gemini Turbo Prop GTP-350, a single-engine, four place light plane. The work established tht STF technology aircraft can have STOL characteristics, can have better ride quality and greater safety margins than conventional airplances, and can meet all applicable airworthiness requirements. Adaitionally, basic design parameters were developed which apply to all STF technology designs. The examination of the marketplace, concluded that military and unmanned aircraft applications were most promising. At the close fo the project, Daedalus research entered into a partnership with SAI Corporation to market the STF concept to the defense establishment.

FY-85 Phase II

Project Title: A Low-Cost Optical Weather Identifier for an Automated Weather Observing System

Principal Investigator: Ting-i Wang

Company: Dynamics Technology , Inc.
21311 Hawthorne Blvd., Suite 30
Torrance, California 90503

Contract Number: DTRS-57-C-00131

Period of Performance: 1 Oct 85 - 30 Sept 87

Technical Monitor: S. Imbembo, APM-650

Summary of Completed Project: This study completed a theoretical analysis, a system design, and laboratory and field tests to investigate the feasibility of the design and fabrication of a low-cost, compact optical weather identifier. The major advantage of the instrument is its ability to perform several present weather monitoring functions, including precipitation state and type identification. Rainfall rate, snow intensity, and visibility measurements are also performed with this device. Integrating these functions into one instrument leads to significant savings, not only in equipment cost, but also in operating costs. A detailed integrated system design has been completed. Dynamics Technology has constructed several field prototype units and installed them at the National Weather Service site in Sterling, Virginia and at Otis Air National Guard Base, Massachusetts. These field tests enabled statistical data to be accumulated for algorithm development and performance evaluation. The test results indicated that the optical weather identifier is a reliable and sensitive sensor for precipitation identification and visibility measurements.

FY-85 Phase II

Project Title: Icing Monitoring Equipment

Principal Investigator: Otakar Jonas

Company: Jonas, Inc.
1113 Faun Road
Wilmington, Delaware 19803

Contract Number: DTRS-57-85-C-00135

Period of Performance: 1 Oct 85 - 30 Sept 87

Technical Monitor: E. Schlatter, ACD-230

Summary of Completed Project: The objective was to finish development and field test an automatic, remote-sensing icing detection device for road and airport surfaces, aircraft wings, and engines. Project goals included surveys of current practices and needs, prototype design, laboratory field testing, selection of manufacturing methods, and a formulation product specifications. The objective and goals were met and a product has been developed which is ready for commercialization.

Results of numerous laboratory and field tests confirm that the icing detector can detect air, water, and ice during actual and simulated weather conditions. It is insensitive to chemical, dirt, and oil contamination; the detecting probes do not disturb ambient flow and temperature conditions. This icing monitor meets all the specifications currently envisioned by the U.S. Government.

The Jonas icing monitor is among the fastest and most sensitive in its response to ice accretion. It employs the conductivity measurement principle. It can detect as little as .02 mm average ice thickness on the detecting probe. The response time in the laboratory water freezing tests was less than one second and in the icing wind tunnel test about three seconds. Potential applications include runways, taxiways, wings, engine inlets, and other exposed aircraft structures.

FY-85 Phase II

Project Title: Onboard Wake Vortex Avoidance System

Principal Investigator: Alan J. Bilanin

Company: Continuum Dynamics, Inc.
P. O. Box 3073
Princeton, New Jersey 08540

Contract Number: DTRS-57-85--C-00019

Period of Performance: 30 Oct 84 - 30 Apr 85

Technical Monitor: P. Massoglia, AES-320

Summary of Completed Project: Existing analytical models of aircraft vortex wake dynamics were assembled to predict the evolution and decay of two commercial jetliner wakes. The calculations undertaken demonstrated that aircraft configuration characteristics, such as engine placement and wing-load distribution, can significantly influence the early stages of wake decay. This study concluded that it is possible and practical to develop a computer design tool capable of assessing wake intensity for existing and future jetliners.

FY-85 Phase I

Project Title: Speech Recognition in Air Traffic Control

Principal Investigator: Sandra E. Hutchins

Company: Emerson & Stern Associates
10150 Sorrento Valley Road, #210
San Diego, California 92121

Contract Number: DTRS-57-85-C-00122

Period of Performance: 1 Oct 85 - 31 Mar 86

Summary of Completed Project: This research was aimed at combining several state-of-the-art speech recognition techniques to produce reliable, real-time speech recognition in the air traffic control (ATC) environment. To assess the value of "capturing" data contained in already required speech, project objectives included the linguistic analysis of air traffic control speech and a human factors review of the consequences of reducing the time now spent re-entering spoken data through a keyboard.

The research methodology involved the creating an ATC "grammar" based on 20 hours of audiotapes from a wide variety of ATC speakers and situations. From that database, 100 representative samples were extracted for detailed computer analysis. Speech editing tools were written to provide pitch and gain display, phonemic marking, and speech playback of these samples, all of which were digitized using a commercial system. These samples were then subjected to various algorithms that reduced noise, tracked pitch, analyzed the speech spectra, and mapped the results into syllabic tables. Audiotape-based work was supplemented through site observations.

Although the analyses were not run in real-time, it is apparent from the research that it is possible to do so. Furthermore, the proposed syllable grammar is nearly speaker independent, suggesting that this approach will be able to overcome the environmental challenges of air traffic control (multiple voices, noise) and its psychological or physical stresses (peak traffic periods, colds), while meeting the needs of error-resistant operation.

FY-85 Phase I

Project Title: Solid State Optical Automatic Icing Detection Instrument

Principal Investigator: Samuel C. Wu

Company: First Omega Group, Inc.
10205 W. Exposition Ave.
Lakewood, Colorado 80226

Contract Number: DTRS-57-85-C-00126

Period of Performance: 1 Oct 85 - 1 Apr 86

Summary of Completed Project: This research investigated the use of an optical fiber sensor in conjunction with specially designed photometric circuitry to detect the presence of ice, independent of temperature conditions at the sensor site. The system was demonstrated to be able to distinguish air, water (including super cooled water), and ice under various conditions without the need for collaborating temperature-sensing devices. The apparatus was capable of detecting the onset, duration, and dissolution of icing. As anticipated, this ice-sensing apparatus did not show sensitivity to the thickness of water or ice in contact with the sensor. Thus, this system alone does not measure ice accumulation or accretion rate. In conjunction with one of the several proven low-cost and high-reliability thickness detection schemes, reliable ice accretion measurements can be obtained.

FY-85 Phase I

Project Title: Integrated Flight Navigation/Guidance Technology

Principal Investigator: Frank C. Genovese

Company: Genovese Associates
17 Selborne Chase
Fairport, New York 14450

Contract Number: DTRS-57-85-C-00125

Period of Performance: 15 Oct 85 - 15 Apr 86

Summary of Completed Project: This project demonstrated the feasibility of integrating microwave landing system (MLS) capability into a semi-automatic microprocessor-based system providing instrument landing systems (ILS) and en route navigation for light aircraft. The purpose of the system was to increase navigation precision and simplicity, improve functional capability and safety margins, and reduce pilot workload and blunder potential, especially in single-pilot instrument flight rule operations.

The research considered methods of determining aircraft angle from the MLS signal. A systems approach was established that minimized receiver hardware by sharing subsystem functions common to the microwave, VHF, and UHF signals. A central processing and display system was responsible for integrating MLS data with VOR and ILS input. The pilot was shown an integrated pictorial display that was easy to interpret and required minimum pilot interaction, reducing the chance for input error. Critical information was duplicated on an auxiliary display which acted as a backup for system control and information readout.

Circuitry for conversion of the MLS microwave band to an intermediate frequency range and channel selection was described. Formats for time-sharing the MLS, UHF, and VHF functions and factors affecting information loss were discussed. A method of decoding digital data words, dynamically controlling system gain, and storing swept-beam information without significant loss in angular precision was given. Probable error associated with MLS angle data reduction was considered, and the proposed DME/P subsystem and its error factors were discussed.

FY-85 Phase I

Project Title: Test Methods to Determine the Degree of Asphalt Stripping from Aggregates

Principal Investigator: Patrick B.Kelly

Company: Kelly/Strazer Associates, Inc.
1630 Southwest Morrison Street
Portland, Oregon 97205

and

H & V Materials Research and Development
3187 Northwest Seneca Place
Corvallis, Oregon 97330

Contract Number: DTRS-57-85-C-00170

Period of Performance: 1 Oct 85 - 31 Mar 86

Technical Monitor: H. Tomita, APM-170

Summary of Completed Project: The purpose of this project was to 1) develop an improved test method to quantitatively determine the susceptibility of an asphalt concrete mixture to stripping, and 2) employ the method developed, evaluate procedures, particularly the use of anti-stripping additives, to overcome the tendency of asphalt concrete to strip over the short- and long-term.

The scope of work included an extensive literature review and evaluation of existing test methods, the development and execution of a laboratory test program, and the development of laboratory test equipment for further refinement. Findings resulting from the project included 1) non-destructive diametral repeated load tests in which the resilient modulus of the material measured have a very high potential for identifying mixes that are susceptible to stripping as well as determining the effectiveness of anti-stripping additives, 2) the results of the preliminary laboratory program in which resilient modulus was employed as an indicator of moisture susceptibility (stripping) of asphalt concrete mixtures clearly indicated that air voids and additive type have a profound effect on mix behavior, 3) the results from the preliminary laboratory program indicated that the repeated load diametral test equipment employed in the research program had a very high potential for identifying mixes that strip and determining the effectiveness of anti-stripping agents, and 4) the prototype equipment developed was extremely functional but could be made more "user friendly" by adding digital readout together with improved data acquisition techniques.

FY-85 Phase I

Project Title: An Ice Accumulation Sensor for Implantation in Airport Runways

Principal Investigator: Loren D. Nelson

Company: OPHIR Corporation
7333 West Jefferson Avenue, Suite 210
Lakewood, Colorado 80235

Contract Number: DTRS-57-85-C-00129

Period of Performance: 1 Oct 85 - 31 Mar 86

Summary of Completed Project: This project studied the feasibility of a runway-implantable sensors used for measuring ice accumulation on airport runways and navigation aid structures.

During this research effort prototype hardware was fabricated and demonstrated in the laboratory. The research showed that it is feasible to detect ice in a mixed sample of ice, air, and water. It was determined that the sensor technology can compensate for the interfering effects of dielectric polarization, DC conductivity, liquid-water and dirt accumulations, and insulation-caused artificial Debye-dispersions.

Laboratory tests and theory indicated it is possible to extend preliminary results to simultaneous real-time ice and water accumulation sensing at the surface of runways with a flat plate sensor embedded in the runway and exposed to the environment. With some minor refinements to the preliminary design the prototype system can be converted into field testable unit.

Project Title: Polymer Concrete Development and Characterization

Principal Investigator: Krish Pandalai

Company: Pandalai Coatings Company
837 Sixth Avenue, Box 100
Brackenridge, Pennsylvania 15014

Contract Number: DTRS-57-85-C-00171

Period of Performance: 1 Oct 85 - 31 Mar 86

Summary of Completed Project: Polymer concrete formulations were made with epoxy and other resins using different ratios of polymer, aggregate, and sand. Thermal expansion coefficient measurements of these samples showed that the addition of polymer to aggregate and sand increased the value of the thermal expansion coefficient beyond that of portland cement concrete. This result was expected since the expansion coefficient value for polymer alone was several times higher than portland cement concrete. However the addition of certain materials like silica and other fibrous ingredients lowered the value of the expansion coefficient close to that of portland cement concrete. There were no data published in the literature on thermal expansion coefficients of modified concrete.

Negative thermal expansion value was been reported in the literature for graphite epoxy material. The shrinkage was attributed to the stiffness of the graphite fiber. Incorporation of fibrous material did not produce a polymer concrete with negative thermal expansion value in the present study, but it reduced the value and brought it close to that of portland cement concrete.

FY-85 Phase I

Project Title: Infrared Ice Accretion Measurement System

Principal Investigator: Abbas M. Sinnar

Company: Sinnar Associates
10076 Shaker Drive
Columbia, Maryland 21046

Contract Number: DTRS-57-85-C-00120

Period of Performance: 1 Oct 85 - 31 Mar 86

Technical Monitor: S. Agrawal, ACD-110

Summary of Completed Project: Remote runway surface condition sensors that could detect ice onset and monitor its rate of accretion on airport pavements would enhance runway safety while reducing airport equipment, manpower, and chemical costs. The main objective of this research was to demonstrate the concept feasibility of the proposed infrared ice accretion measurement system using a laboratory breadboard experimental setup.

In this project, a laboratory test setup consisting of state-of-the-art equipment was designed, and the transmittal of water, ice, and various deicers were measured between 1 and 2 microns to determine their absorption coefficients. Then, at two selected wavelengths, icing/deicing and frosting/defrosting tests were carried out to determine the concept feasibility of the proposed system.

The research first confirmed the existence of "sought-for" differences between absorption coefficients of ice and water, then it successfully demonstrated the application of these differences in onset detecting and monitoring of icing and deicing processes. The research further utilized the unique transmittance characteristic of frost formation to distinguish it from icing processes.

FY-85 Phase I

Project Title: Adhesive Materials for Sealing Conductors and Light Units in Airport Pavements

Principal Investigator: William Holley

Company: Springborn Laboratories, Inc.
10 Springborn Center
Enfield, Connecticut 06082

Contract Number: DTRS-57-85-C-00127

Period of Performance: 30 Sep 85 - 31 Mar 86

Technical Monitor: A. McLaughlin, ADS-240

Summary of Completed Project: Knowledgeable FAA personnel were interviewed regarding saw kerf fillings and landing light embedment. Problems and present technology were discussed. One- and two-part sealant systems, including hot melts and UV cure one-part systems, were evaluated for adhesion to asphalt sealant tensile properties including modulus and coefficient of expansion, casting properties. Sections of bituminous concrete runway were also evaluated for tensile properties and coefficient of expansion.

Epoxies have very good adhesion to bituminous concrete and are reasonably trouble free unless poorly mixed. Preliminary indications are that the coefficient of expansion mismatch can be overcome by the addition of small glass beads. One or more ingredients in the commonly used unsaturated polyester appeared to injure the asphalt due to a solvent effect. However, this solvent effect appeared to diminish with time. Preliminary indications are that urethane and polysulfides may be suitable for runway use, but care must be taken in the formulation of the sealants/adhesives to avoid diluents, etc., that attack asphalt.

One part systems such as amine-blocked, moisture-cure silicones, isocyanates, hot melts, UV cure, and possibly polysulfides show preliminary promise for saw kerf filling. The silicones, isocyanates, and polysulfides are much too slow setting for runway light embedment. Whether hot melts could be used for setting runway lights was undetermined. The commercial liquid one-part systems are not suited to saw kerf use.

FY-85 Phase I

Project Title: Integrated Navigation Data Reporting for Oceanic ATC Surveillance

Principal Investigator: Bryant D. Elrod

Company: Stanford Telecommunications, Inc.
6888 Elm Street
McLean, Virginia 22101

Contract Number: DTRS-57-85-C-00121

Period of Performance: 1 Oct 85 - 30 Apr 86

Summary of Completed Project: This project investigated an approach for supporting automatic dependent surveillance (ADS) in transoceanic airspace and areas with ATC coverage gaps. The technique utilized an onboard navigation data reporter (NAVREP) to provide consolidated position reports together with an assessment of data integrity.

The research focused on 1) the functional definition of NAVREP algorithms for onboard navigation data integration and fault detection isolation, 2) the definition of NAVREP message contents compatible with current/projected ATC needs, 3) analysis of data link requirements, and 4) assessment of NAVREP feasibility based on top-level design requirements.

Study findings indicated that the overall NAVREP concept was feasible with respect to interface design, processor speed, memory requirements, and development risk. Additional study is needed to refine the software structure and hardware requirements for an operational system. In particular, the utility of expert system methodologies to filter multiple navigation data streams needs to be evaluated.

FY-85 Phase I

Project Title: Expert Systems Applications for Air Traffic Control: A Feasibility Analysis

Principal Investigator: Arthur Gerstenfeld

Company: UFA, Inc.
710 Commonwealth Avenue
Newton, Massachusetts 02159

Contract Number: DTRS-57-85-C-00124

Period of Performance: 1 Oct 85 - 15 Mar 86

Technical Monitor: A. Adkins, ACD-340

Summary of Completed Project: This research demonstrated the feasibility of using an expert system to aid in training air traffic controllers. The project developed several scenarios (or training cases) demonstrated how the computer could be programmed to make decisions similar to a highly experienced air traffic controller. This was accomplished by developing a small system (LISP oriented) to provide proof of concept and practice.

In the scenarios, an air traffic controller trainee could vary the arrival rates (handoff times) from en route to approach control. The ATC trainee was then able to make his/her own decision on clearances and compare them with the clearances given from the computer. The system was programmed in several ways to recognize the fact that when a controller issues clearances there is only "one answer".

Project Title: Detection of Drugs in Concealed Compartments

Principal Investigator: Glenn J. Lubrano

Company: Universal Sensors
P. O. Box 736
New Orleans, Louisiana 70148

Contract Number: DTRS-57-85-C-00153

Period of Performance: 1 Oct 85 - 30 Apr 86

Summary of Completed Project: This research was conducted under a cost-sharing arrangement between the Federal Aviation Administration, the Department of Transportation, and the United States Coast Guard. Specific antibodies were tested as selective protein adsorbent coatings for utilization in piezoelectric (PZ) quartz crystal detection systems. Results of this study demonstrated a selective and reversible response of the coated detector to such drugs as cocaine hydrochloride, alkaline cocaine, morphine hydrochloride, and phenobarbital. A specific response to these drugs was achieved using antibody coatings. The responses were fast, completely reversible, sensitive (parts per trillion), and highly selective, thus indicating the viability of the use of protein coatings for the gas phase detection of concealed drugs.

With a 9-MHz crystal as little as one part per trillion of cocaine, morphine, or phenobarbital was detectable. Excellent reproducibility of measurement was observed (3 to 5 percent). By using a higher frequency of crystal, an increase in sensitivity down to 0.01 parts per trillion was feasible. The research demonstrated the viability of the PZ approach to drug detection.

APPENDIX 1

SIGNIFICANT WORK PREVIOUSLY COMPLETED

FY-84 PHASE II

Project Title: Development of a Surface Acoustic Wave Altitude Sensor

Principal Investigator: Edward J. Staples

Company: Amerasia Technology
(formerly Technology Management Associates)
620-1 Hampshire Road
Westlake Village, California 91361

Contract Number: DTRS-57-85-C-00033

Period of Performance: 1 Oct 84 - 30 Nov 86

Technical Monitor: A. Bugie, AAP-500

Summary of Completed Project: A less costly and more accurate aircraft altitude sensor would be a great boon to flight instrumentation. In this Phase I SBIR study, a new type of high accuracy sensor, using surface acoustic wave (SAW) resonator technology, was proposed. Studies showed that SAW resonator sensors could meet the performance goals of avionics air-data instrumentation with higher accuracy, wider operating temperatures and faster warmup time. In Phase II, laboratory prototype sensors were designed, fabricated, and evaluated in terms of altimeter specifications.

Since the SAW sensor output is frequency, it could be easily be interfaced with microprocessors without using A/D converters. With the prototype SAW sensor fabricated in Phase II, 16 bit precision (approximately .001) percent was demonstrated. The major source of error was temperature; hence, a temperature compensation technique was developed which utilized first order analog temperature software. Using temperature-compensation methods, a low-cost prototype air-data sensor with +/- 0.1 ft. resolution error for an altitude of 30,000 ft. was demonstrated.

FY-84 Phase II

Project Title: Tieback Element and Soil Nailing Wall

Principal Investigator: David E. Weatherby

Company: Schnabel Foundation Company
4720 Montgomery Lane, Suite 300
Bethesda, Maryland 20814

Contract Number: DTRS-57-85-C-00040

Period of Performance: 27 Dec 84 -

Summary of Proposed Research: This project researched the development of an innovative earth retention system. Specifically, it related to combining permanent tieback elements with soil nailing to enable the construction of a retaining wall in soils and soft rocks. This earth retention system was built from the top down. As the excavation proceeds, it can be used to stabilize landslides. The project remains incomplete; the final report has not been received.

Anticipated Results: Tieback elements and soil-nailing walls can be used to construct earth retaining walls, reducing the size of the construction easement behind the wall. Tieback elements and soil-nailing walls could be used for the stabilization or preventation of landslides in soilslopes at or around airports.

FY-84 Phase I

Project Title: Rebreathing Device for Use by Passengers in Aircraft Fires

Principal Investigator: Ludwig Wolf Jr.

Company: Wolf Engineering
2116 Nish Road
Crystal Lake, Illinois 60014

Contract Number: DTRS-57-85-C-00010

Period of Performance: 11 Nov 84 - 11 May 85

Technical Monitor: T. Walsh, ADL-5

Summary of Completed Project: The feasibility of developing a rebreathing device for use by airline passengers during in-cabin fires was demonstrated. The device consisted of a modified passenger oxygen mask equiped with a canister containing about 40 grams (1.5 ounces) of lithium hydroxide to absorb the carbon dioxide produced by the passenger. The experiment showed that this device can maintain the carbon dioxide level in the rebreathing circuit below one percent for 15 minutes, the life of the aircraft oxygen supply.

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